Discrete Event ("Network") Modeling, Patient Flow & Irregular Geometries in AnyLogic

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MIT 15.879

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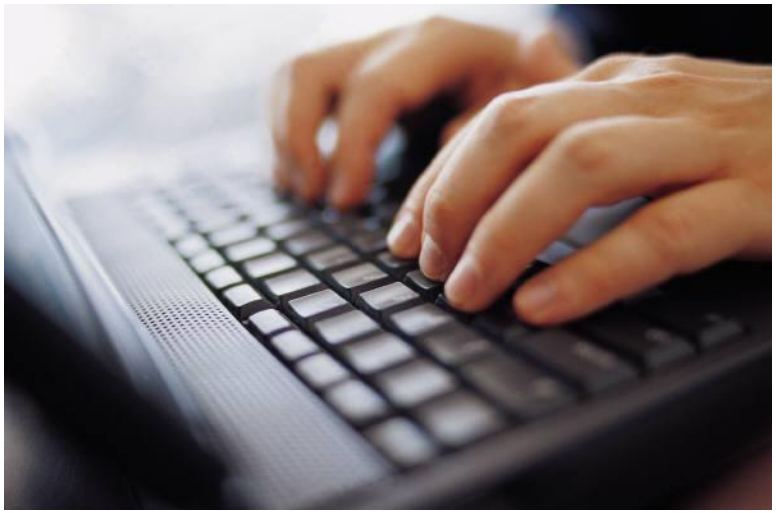
Recall: “Network Modeling”
Irregular Spatial Embedding

Hands on Model Use Ahead

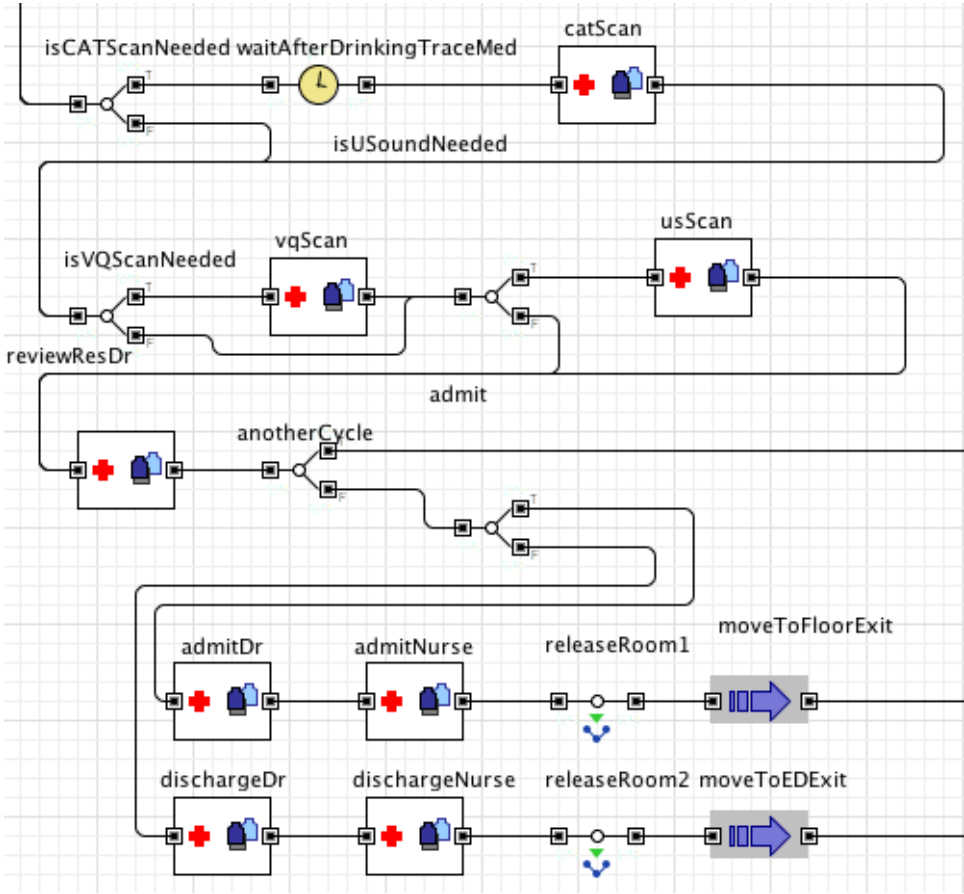


Load model (available on STELLAR Site):

Ophthalmology Department.alp

Discrete Event ("Network Oriented") Modeling

- Resource-based modeling
  - Queues
  - Processes
  - Flow charts
  - Capacitated resource pools
  - Send to
  - Attachment/detachment



Central Concepts in Discrete Event Modeling

- Entities flowing through processes & being processed at successive stages
- Flow charts specify process ("workflow" on entities)
- Resources required for processing
  - Queues for entities awaiting resources
  - Limited-capacity resource pools from which resources are drawn
- Entity interaction with resources
  - Attachment/detachment
  - Seizure
- Physical "homes" for resources
- Movement paths (via polylines)

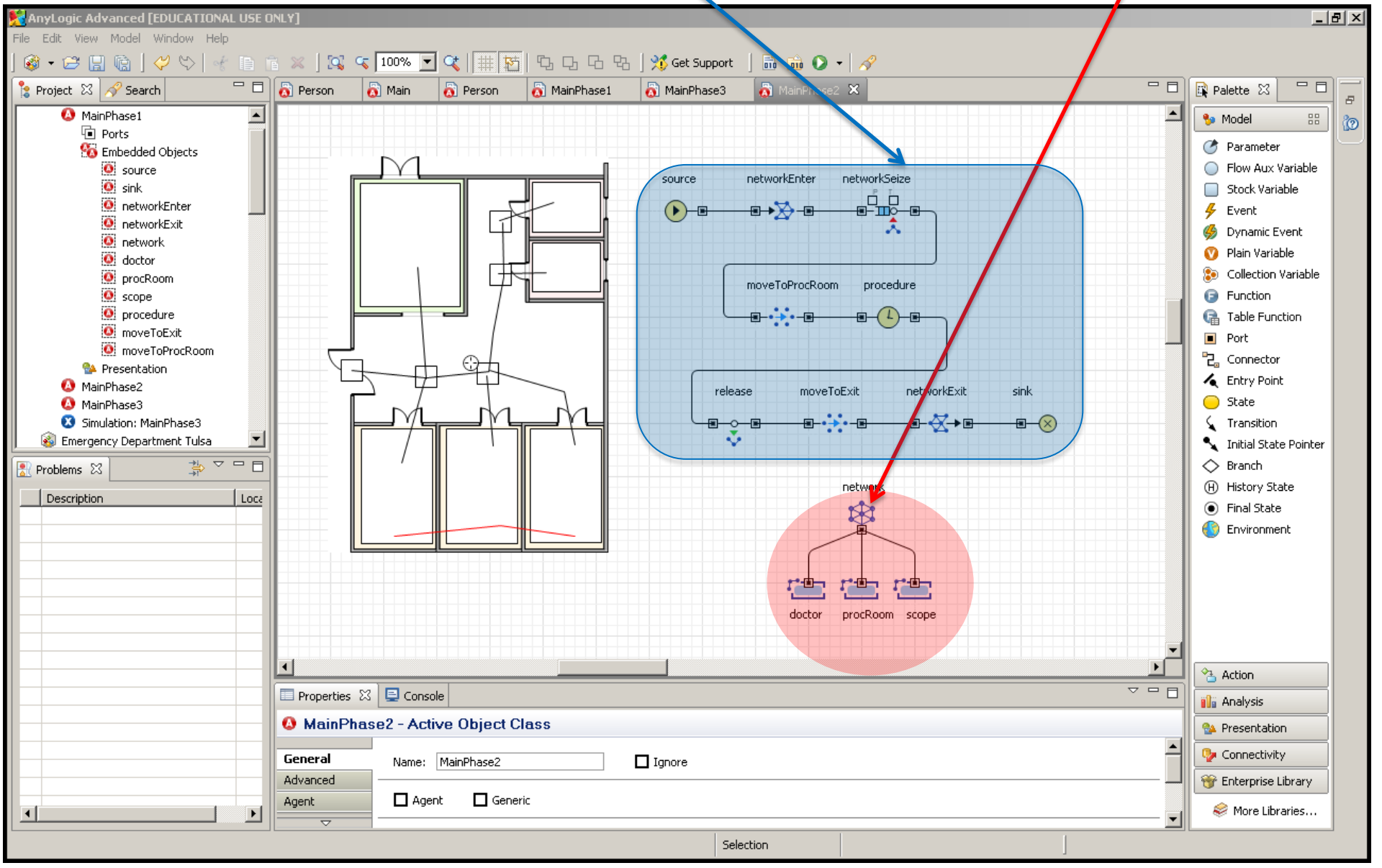
Specifying a “Network”

- A network groups together
  - Entities
  - Resources
  - Portions of the workflow

Flow chart associated with Network (Entities flow through this)

Types of resources associated with the network, each in a resource pool

Network and Its Components



Entities

- Entities are the central parties on which the processes take place
  - eg Patients in a hospital or clinic, cars in an assembly line
- Primarily passive – things "happen to them"
- "Flow through" (are routed around) the flow charts associated with the system
  - "Injected" into the system at a source; disappear at sink
  - Only exist for the duration of time that are in the system
- Multiple entities typically in the system at one time
- If wish to maintain extra information on an entity, can "subclass" the Entity class
- Entities are often associated with a physical representation, which travels around spatial envir.

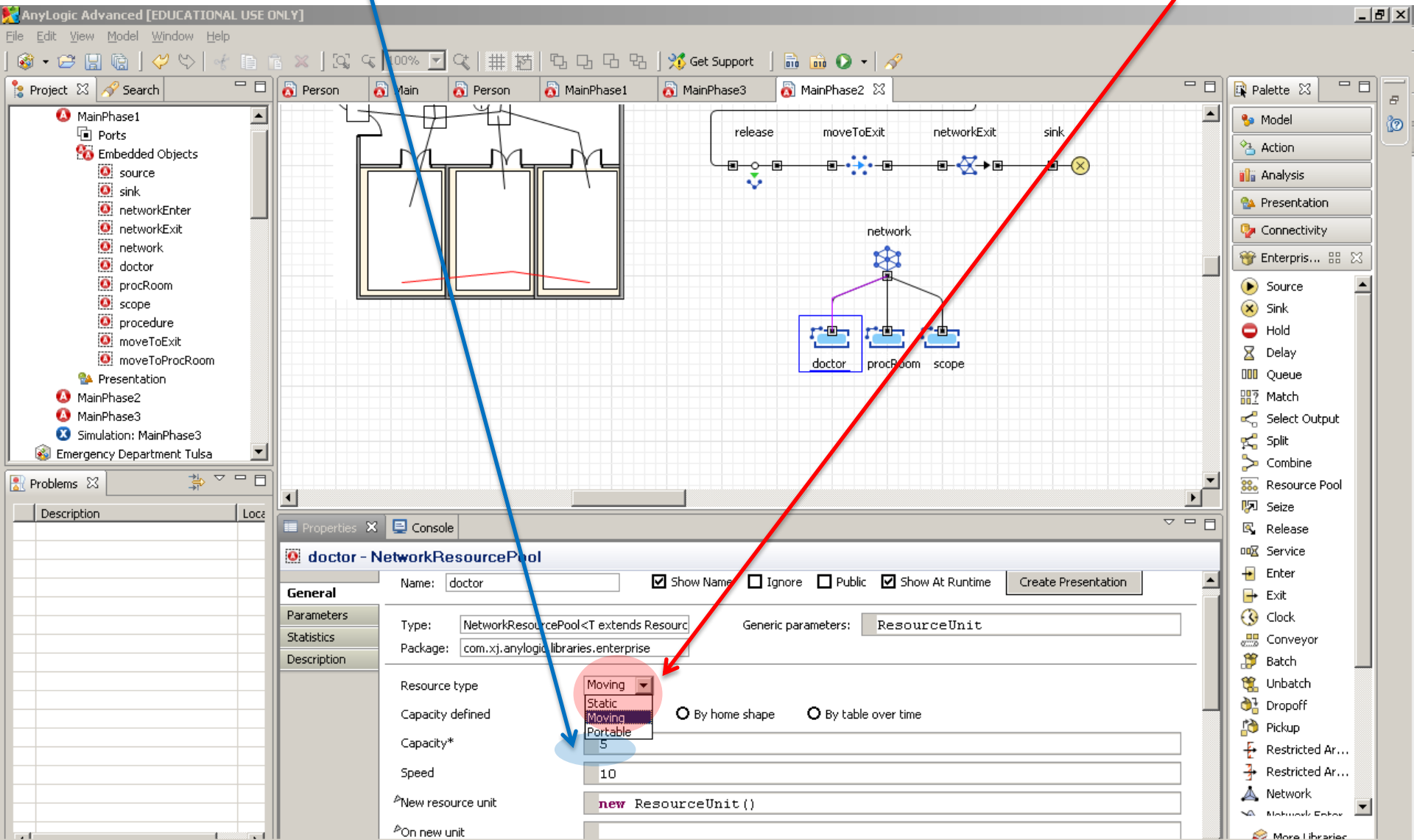
Resources

- Frequently resources are required to initiate a particular phase of processing
  - A doctor (resource) to administer surgery to a patient (entity)
  - A piece of diagnostic equipment (resource) to image a patient (entity)
  - An EKG to (resource) to record from a patient (entity)
  - A gurney or bed (resource) for a patient (entity)
- Distinctions amongst these resources
  - Portable vs. fixed
  - Mobile (with agency)
- To capture these dependencies, a network is often associated with multiple types of resources

Defining Resource Pools

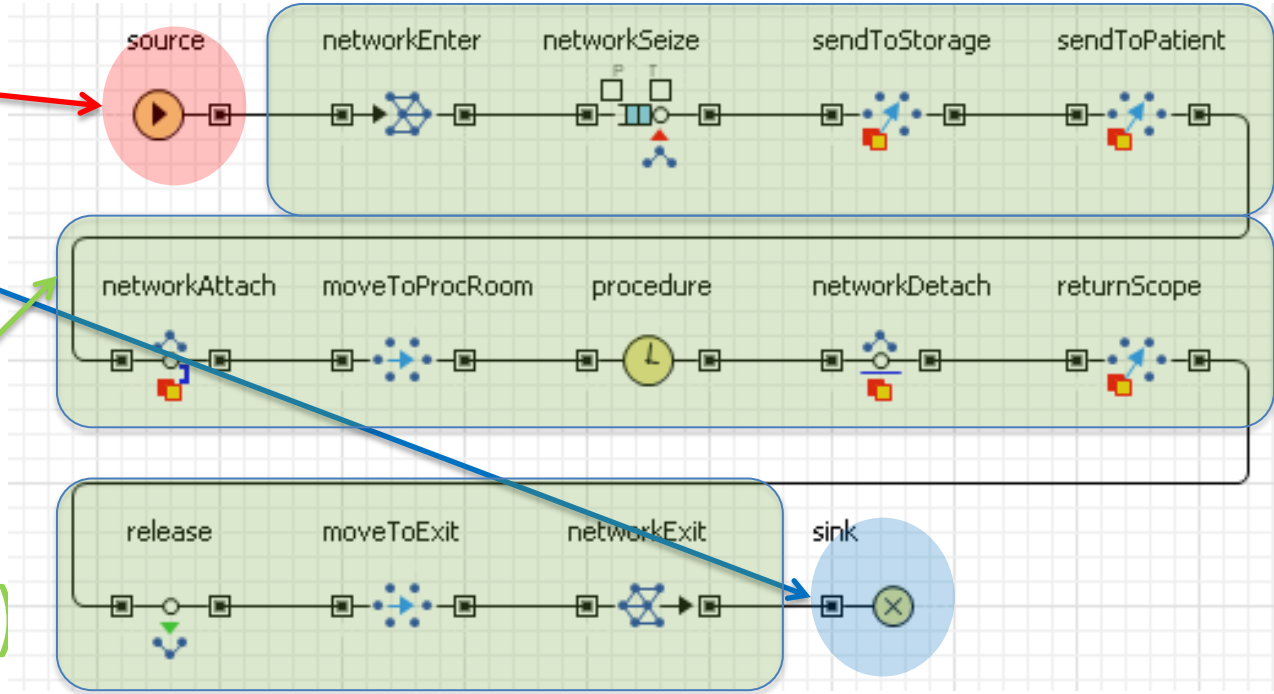
Capacity of Pool (number of units of resource present)

Resource pool type
(Static [Fixed], Moving [Mobile],
Portable [Can be carried])



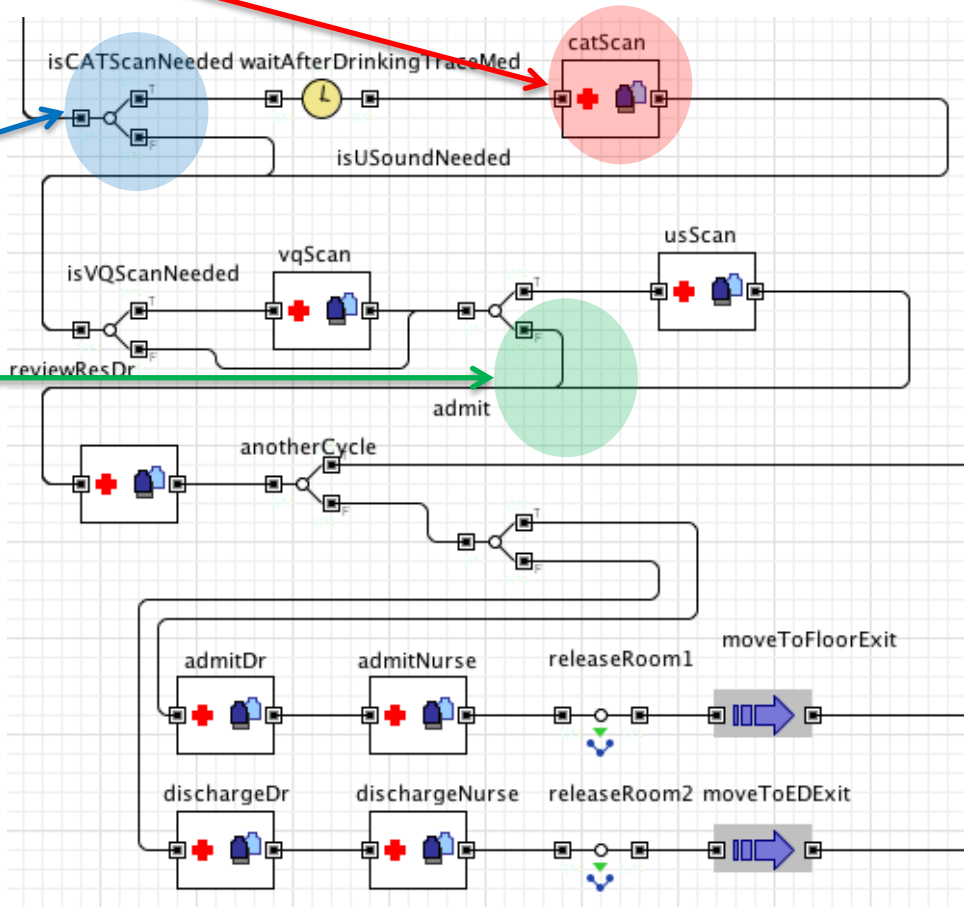
Flow Charts

- Entities flow in a single direction on flow charts
- Start
- Finish
- Intermediate steps (icon indicates semantic kind)

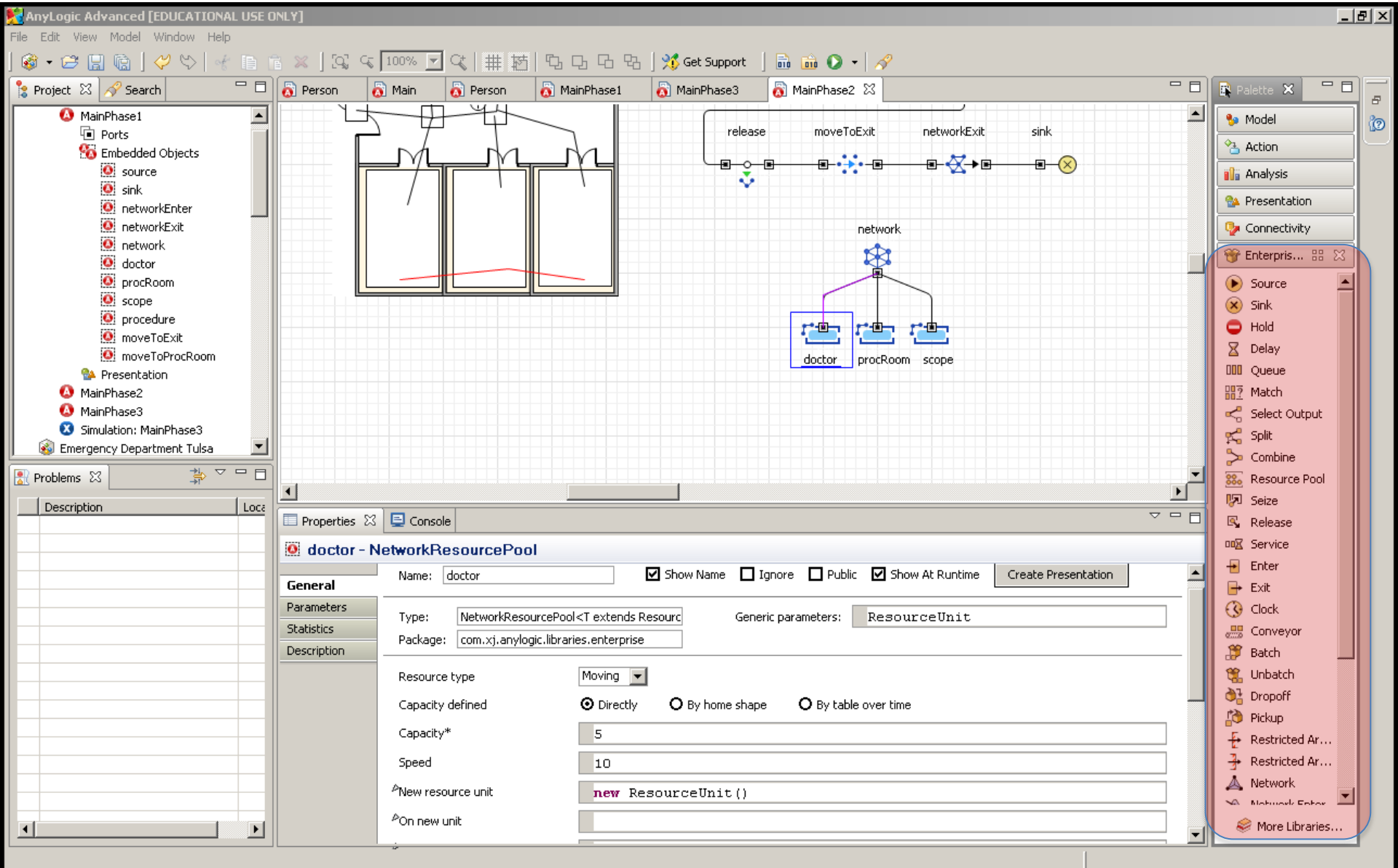


Flow Charts

- Flow charts can be hierarchical
- Frequently not linear e.g.
  - Branches
  - Joins



Palette Elements to Specify Flow Charts

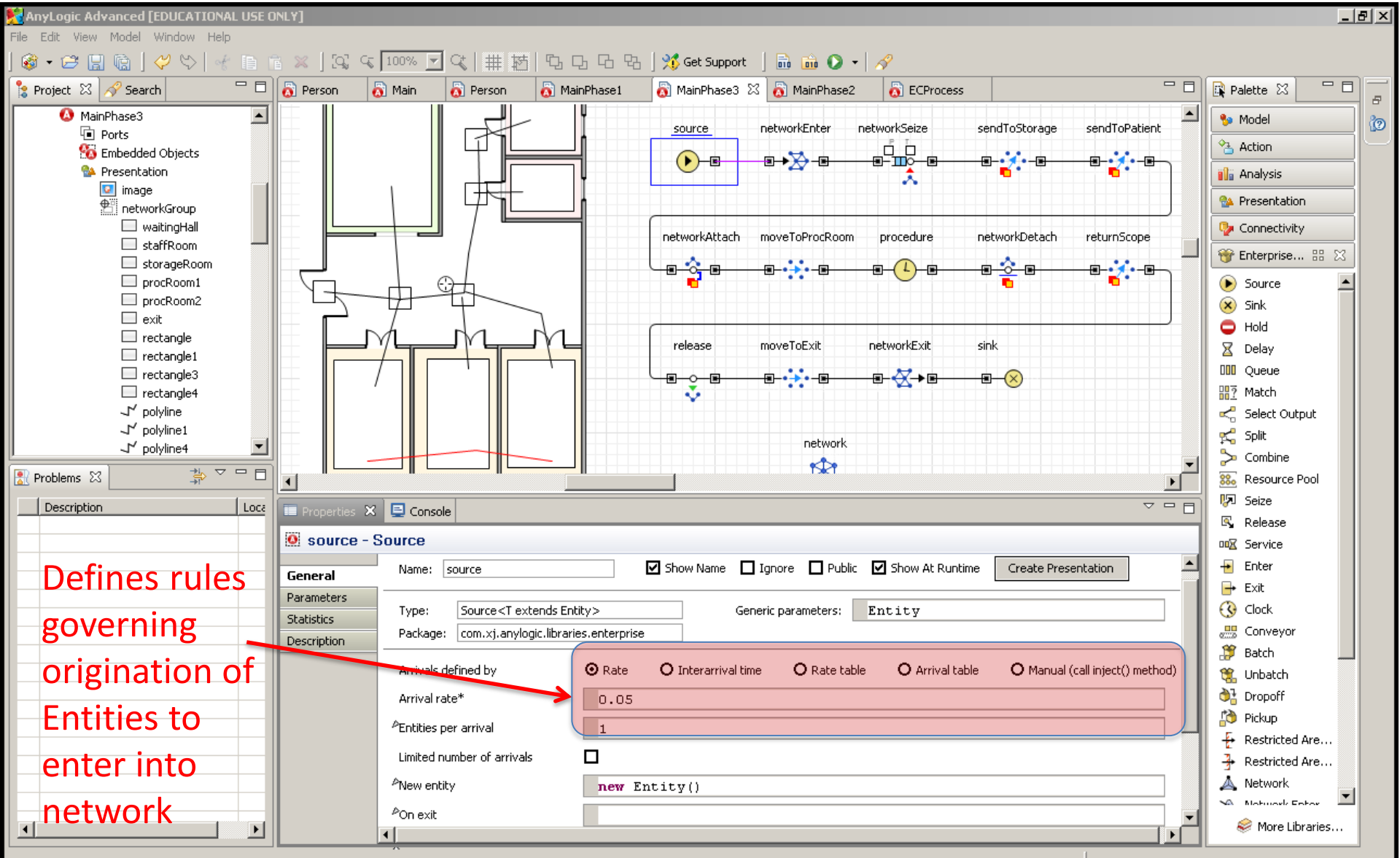


Major Operators of Interest

- Source
- Sink
- Network enter/exit (enter into a particular network)
- Select output (based on predicate)
- Split
- Delay

- Resource-related
  - Network seize/release: Association between Entity & Resource
  - Network attach/detach: Physically link entity & attached resources, so travel with entity
  - Network move to: Move entity (& movable attached resources) to particular place
  - Network send to: Send mobile resources to a location

Source: Entity Origination



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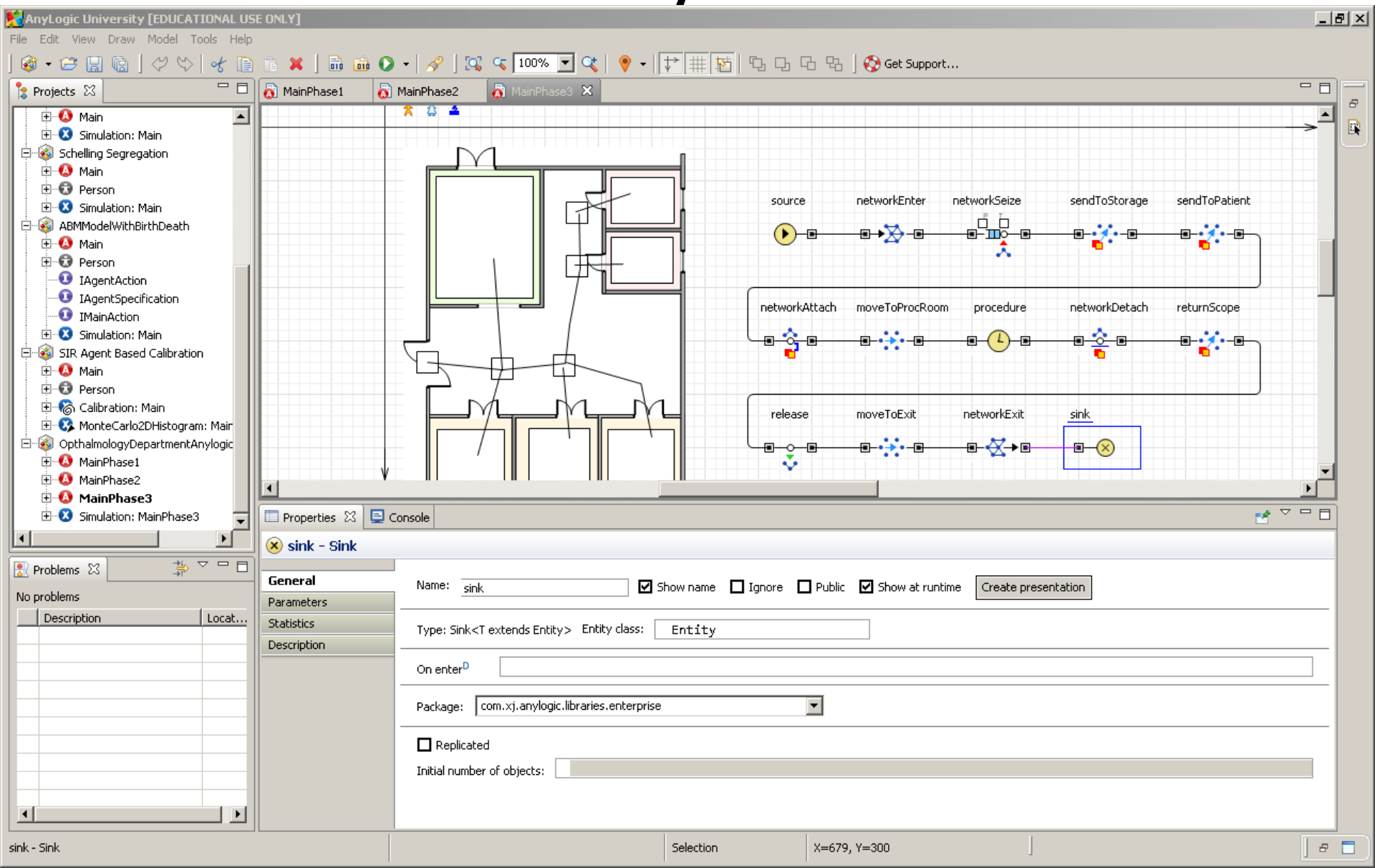
Sink: Entity Cessation



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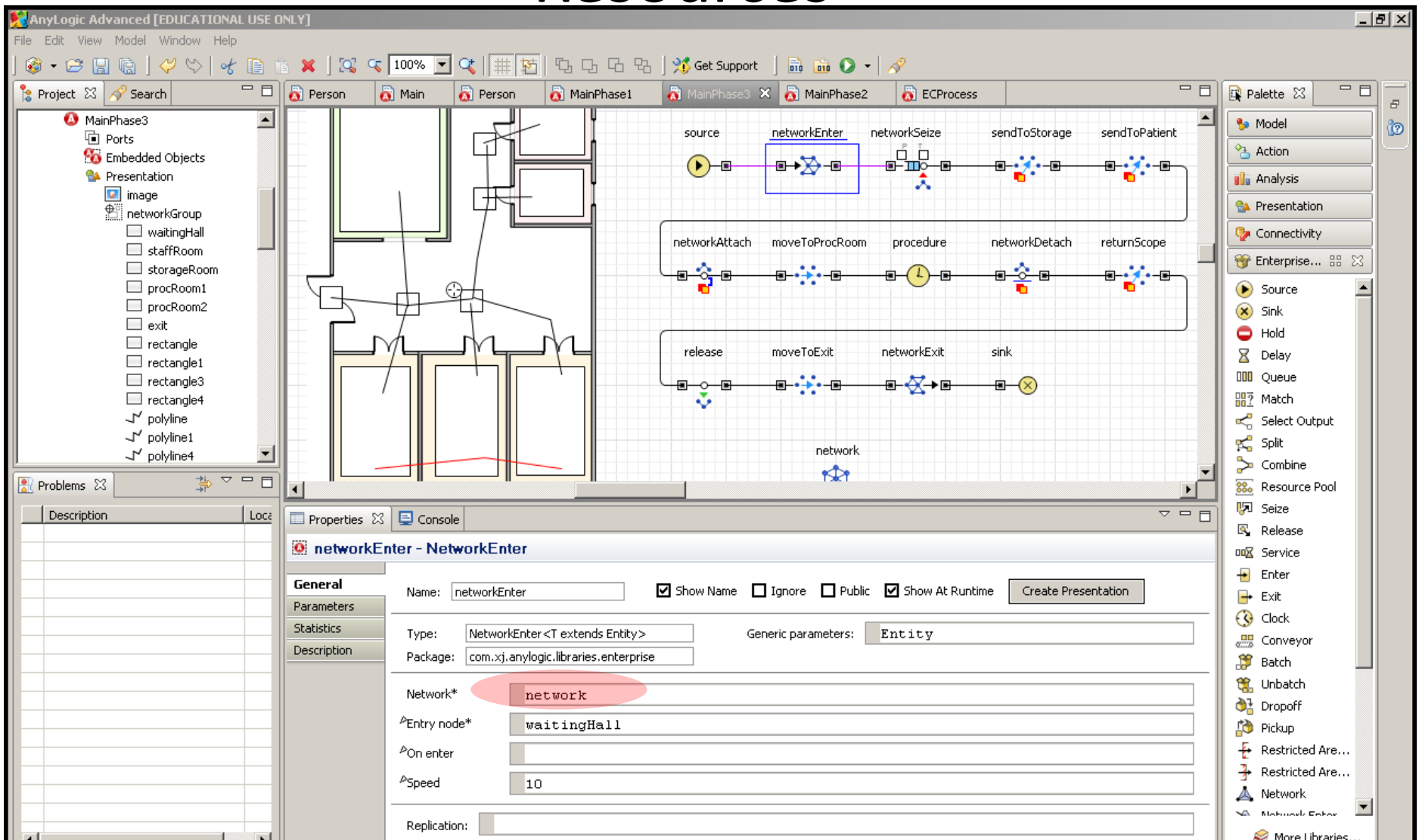
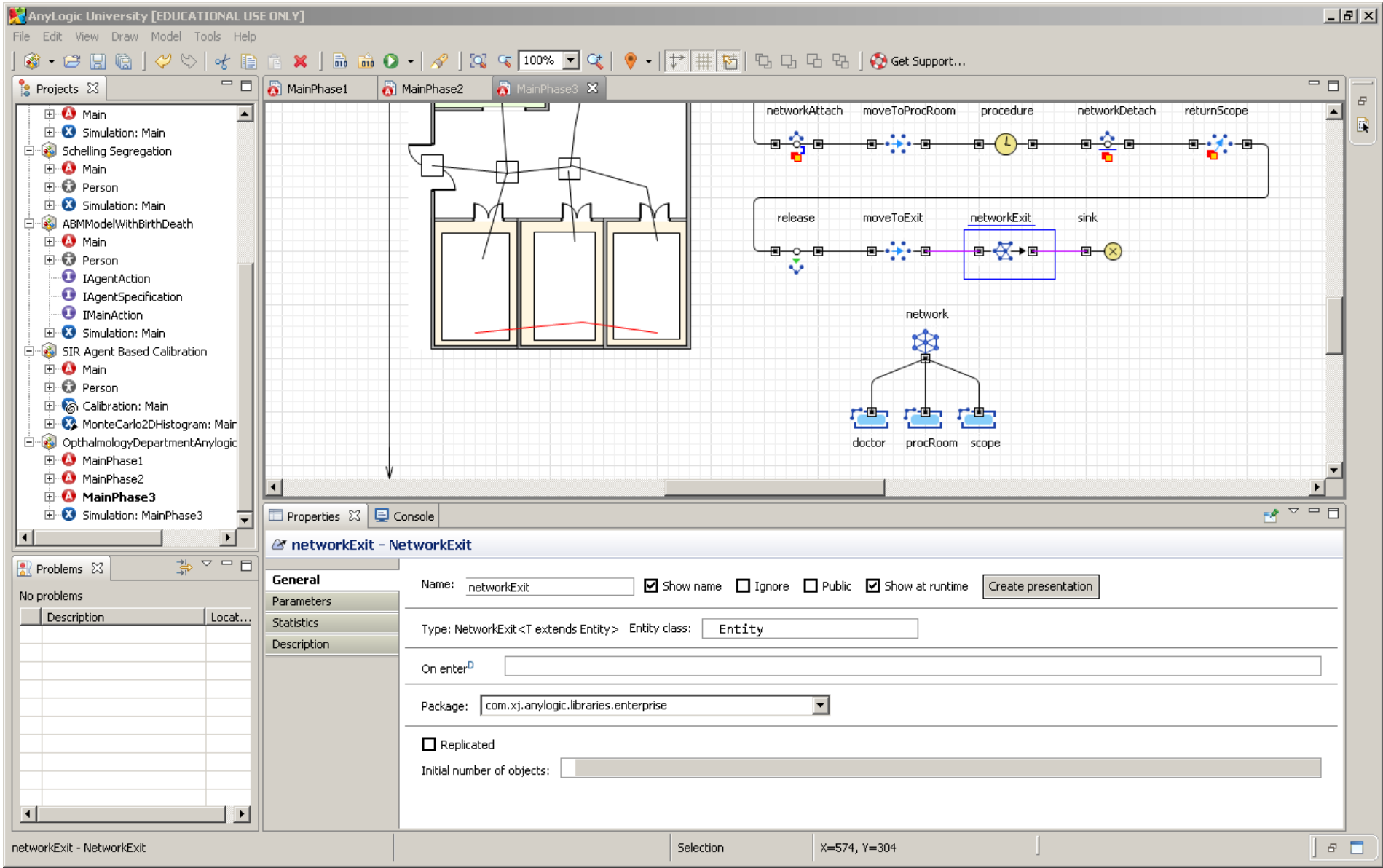
Network Enter: Informing Newly Created Entities of the Available Resources



Network Exit



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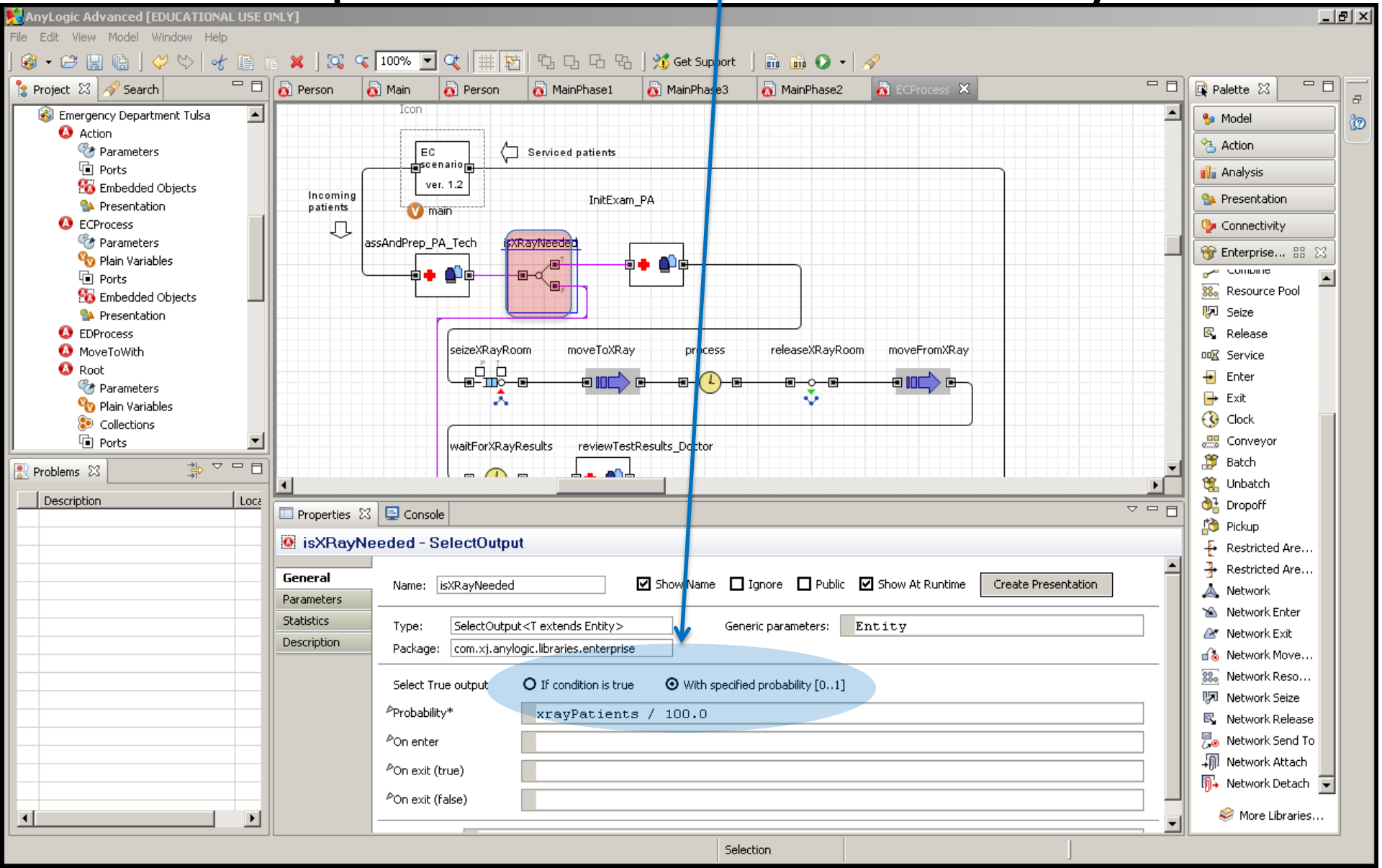
Determining factor can either be deterministic (e.g. based on condition) or stochastic (based on probability)

Select Output: Which Path Does Entity Take?



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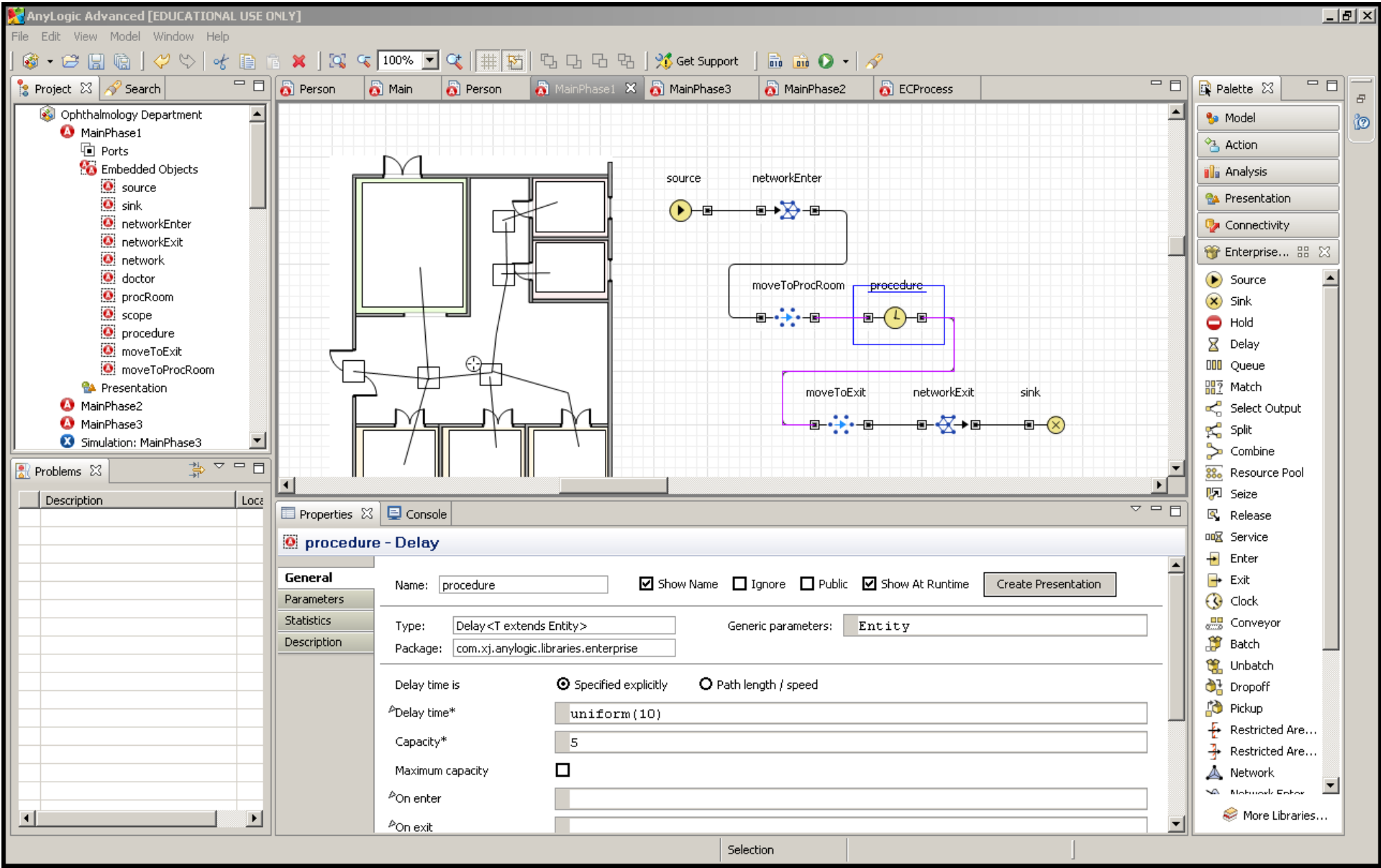
Network Delay



Recall: Resources

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- To capture these dependencies, a network is often associated with multiple types of resources

Resources 2

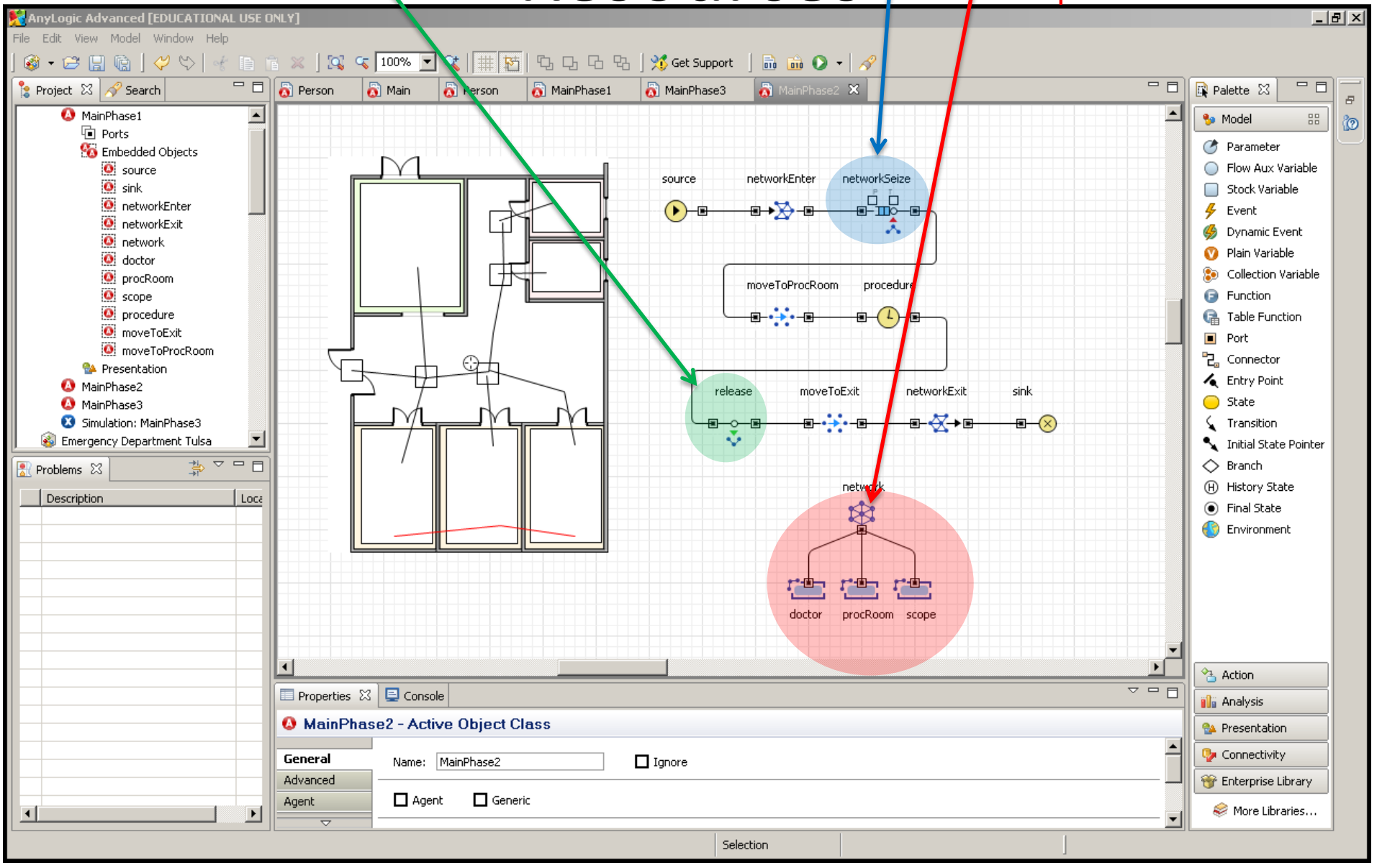
- When an agent cannot obtain (“seize”) a resource, they “enqueue” and wait for that resource to be released by another entity
  - These resources live in “pools” of interchangeable “resource units”
  - A “seized” resource comes from the pool
  - A “released” resource returns to the pool
  - If wish to be able to choose particular resources from a pool, create in *different pools*, and select desired pool

Resources

"Seizes" (seeks to achieve exclusive association with) a resource (otherwise waits)

"Releases" association with a resource, so others can be associated with/use it

Types of resources associated with the network, each in a resource pool



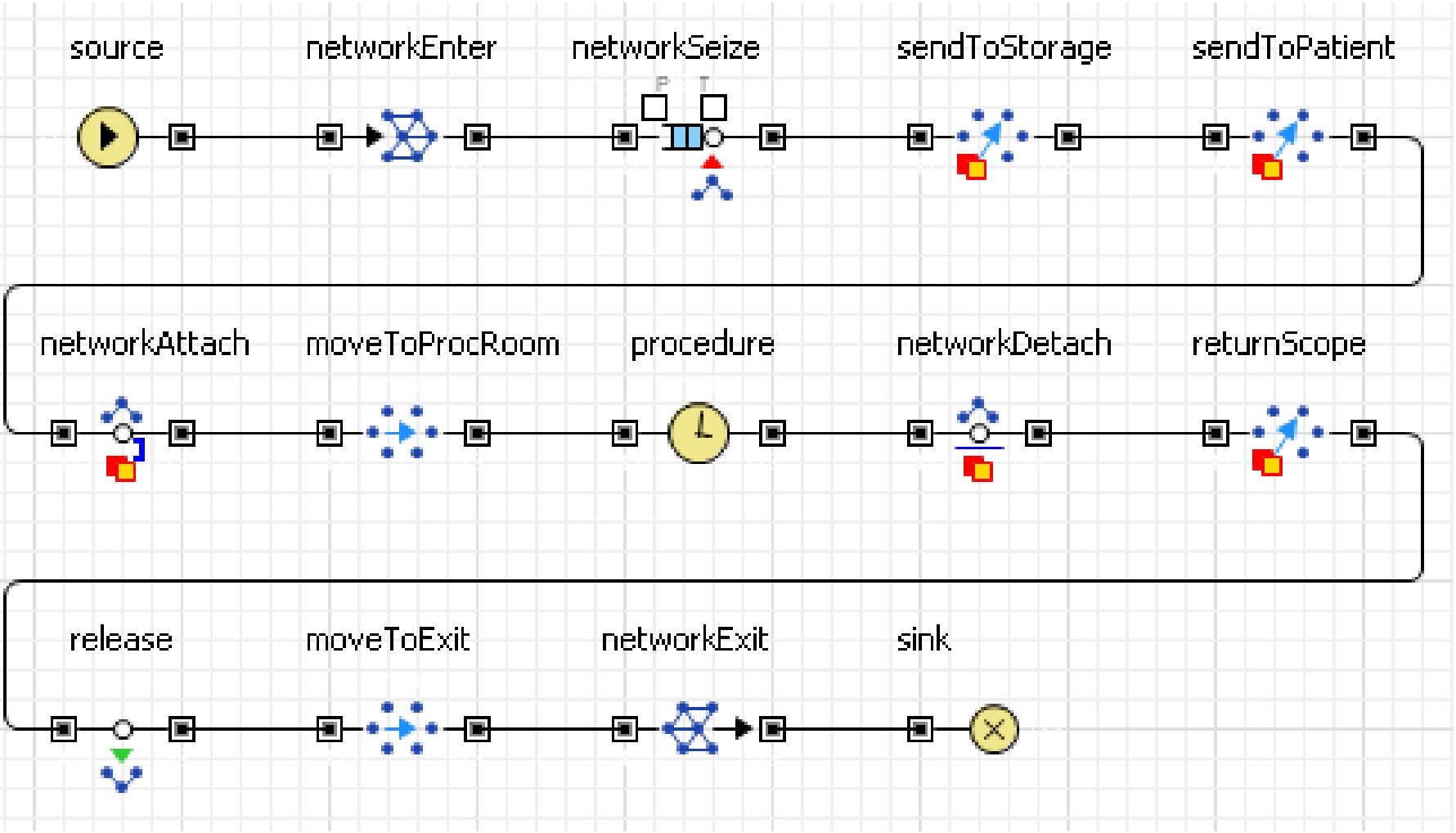
Main Flow Operators Associated with Resources

- All resources
  - Network Seize
  - Network Release
- All non-static (portable&mobile resources)
  - Network Attach (NetworkAttach)/Detach (NetworkAttach)
- Moving entity – along with attached portable & mobile resources – to a location
  - NetworkMoveTo
- Moving mobile resources to a location
  - Network SendTo (NetworkSendTo)

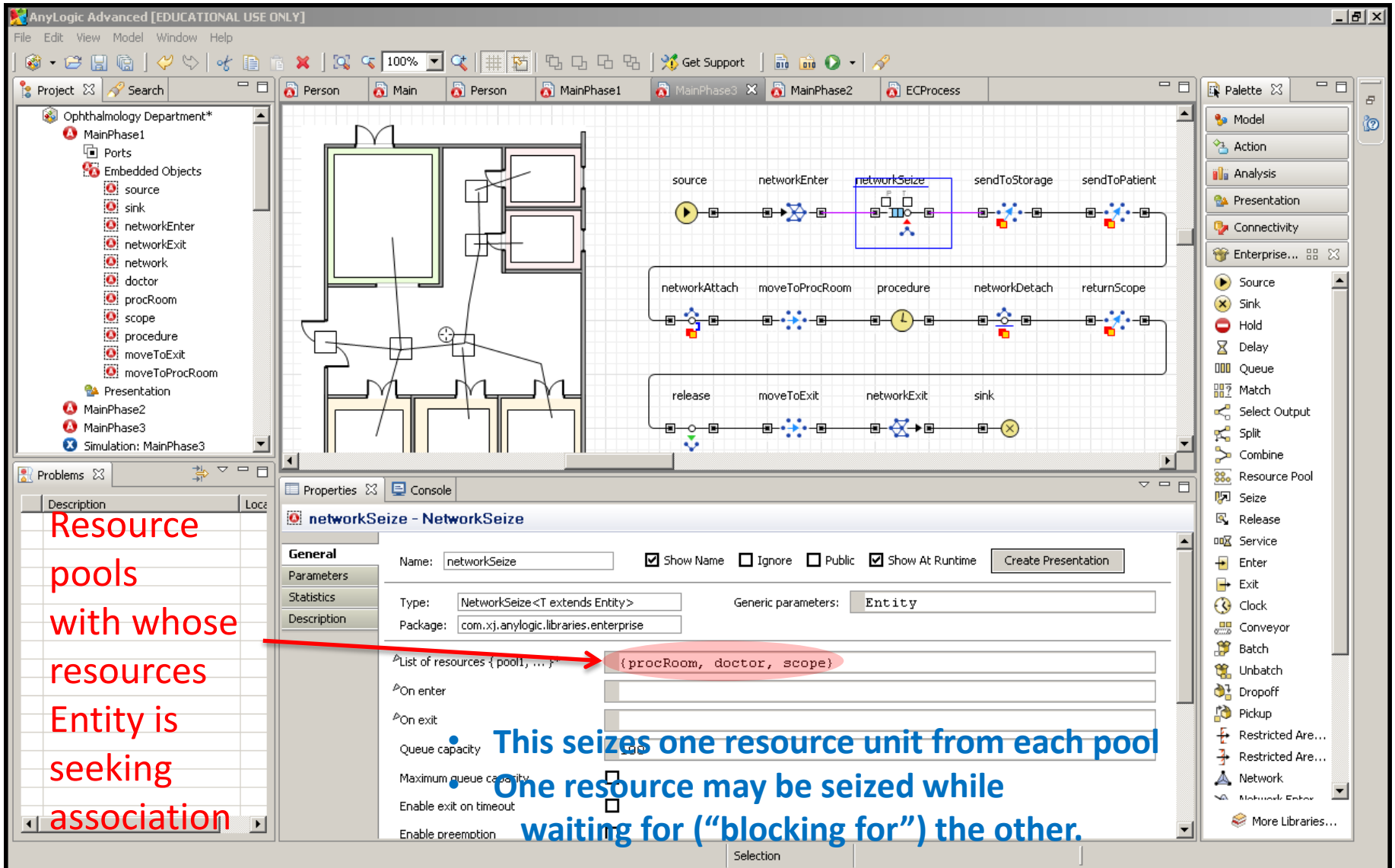
A Key Distinction

- Seizing/Releasing a resource: Is this resource reserved by (uniquely associated with) the entity?
- Attaching/Detaching a resource: Will this resource spatially follow the agent?

Another Flow Chart



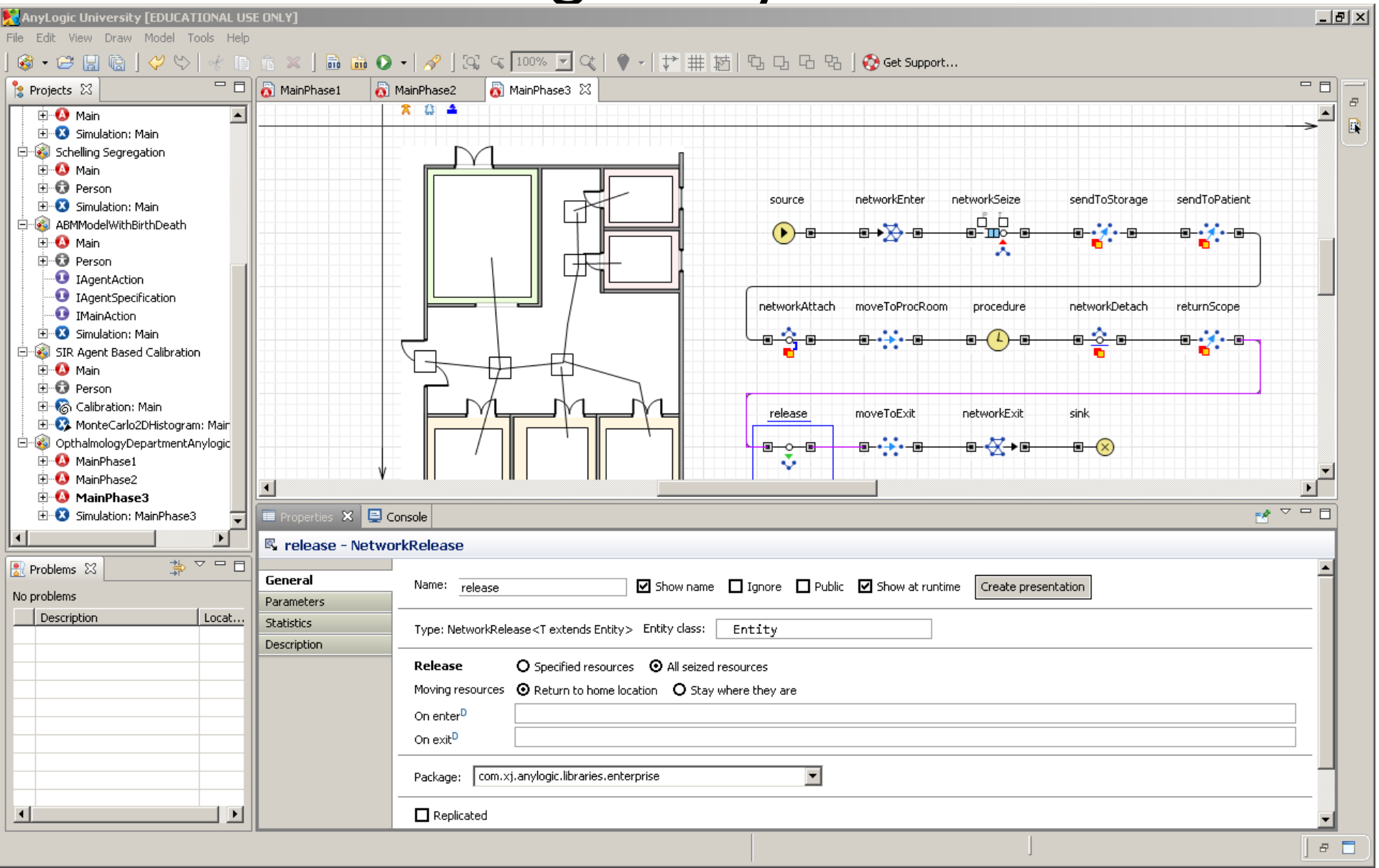
Securing Association with 1 or More Resources: Network Seize



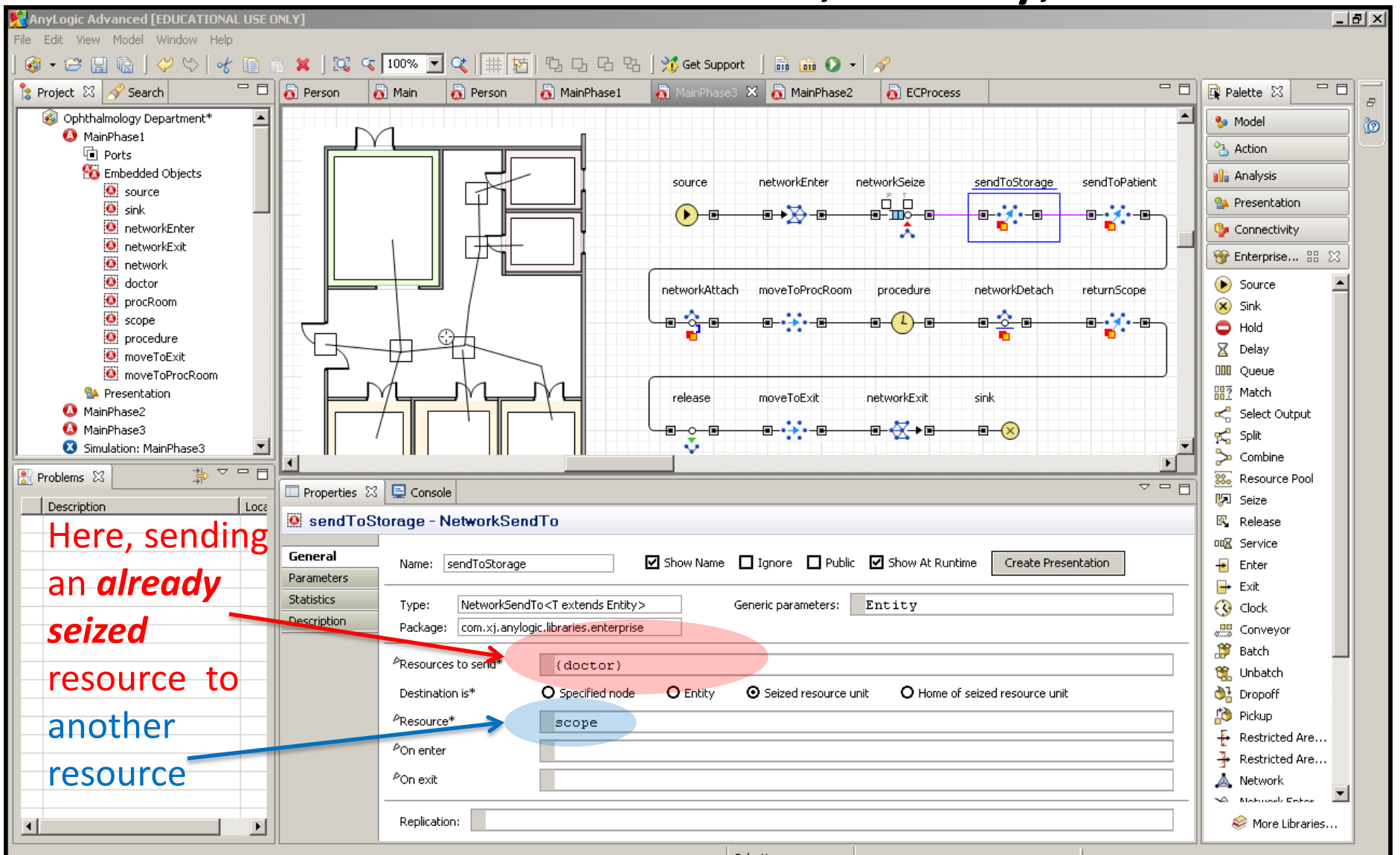
Resource pools with whose resources Entity is seeking association

- This seizes one resource unit from each pool
- One resource may be seized while waiting for ("blocking for") the other.

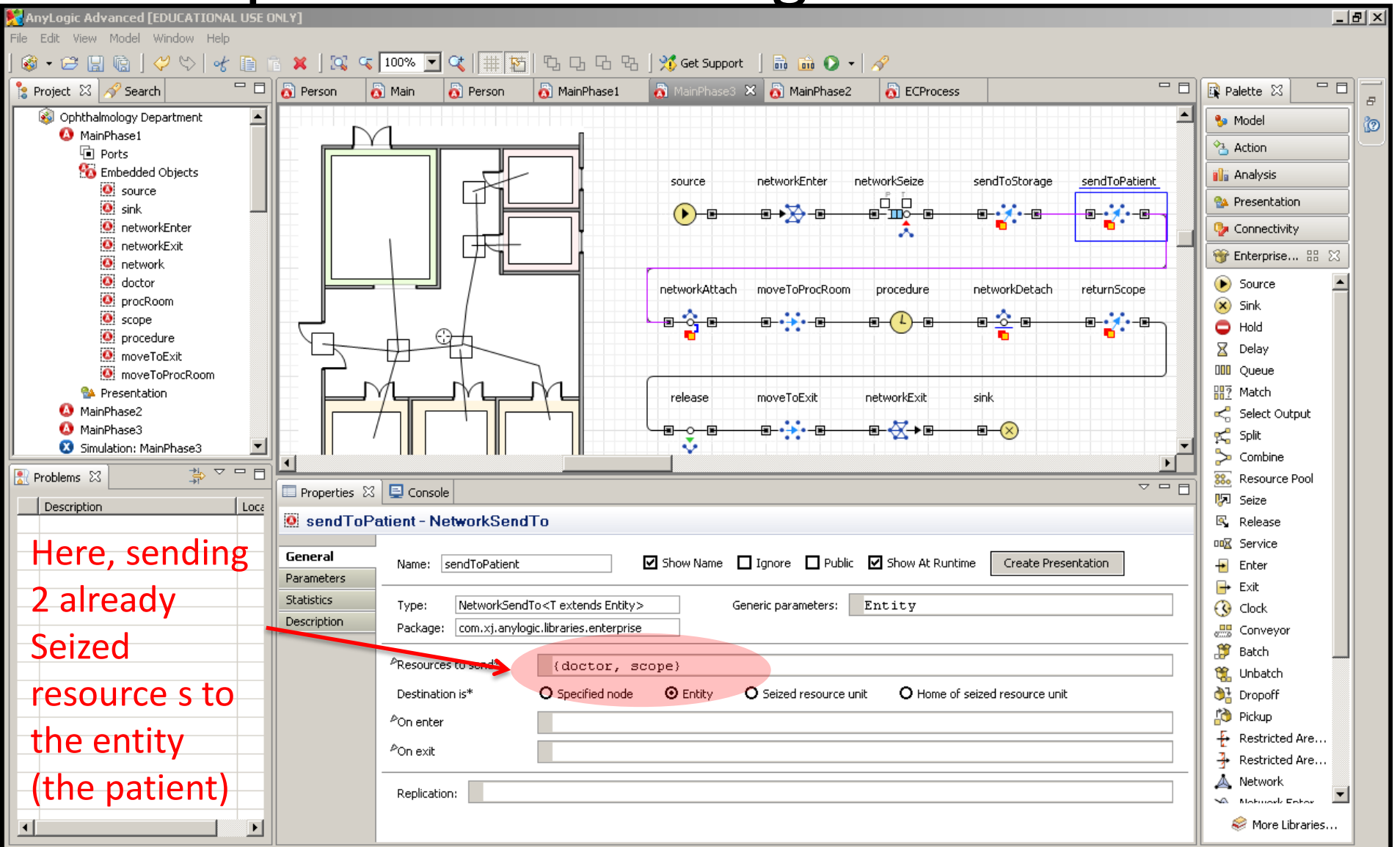
Network Release:
Dissociating Entity & Resource



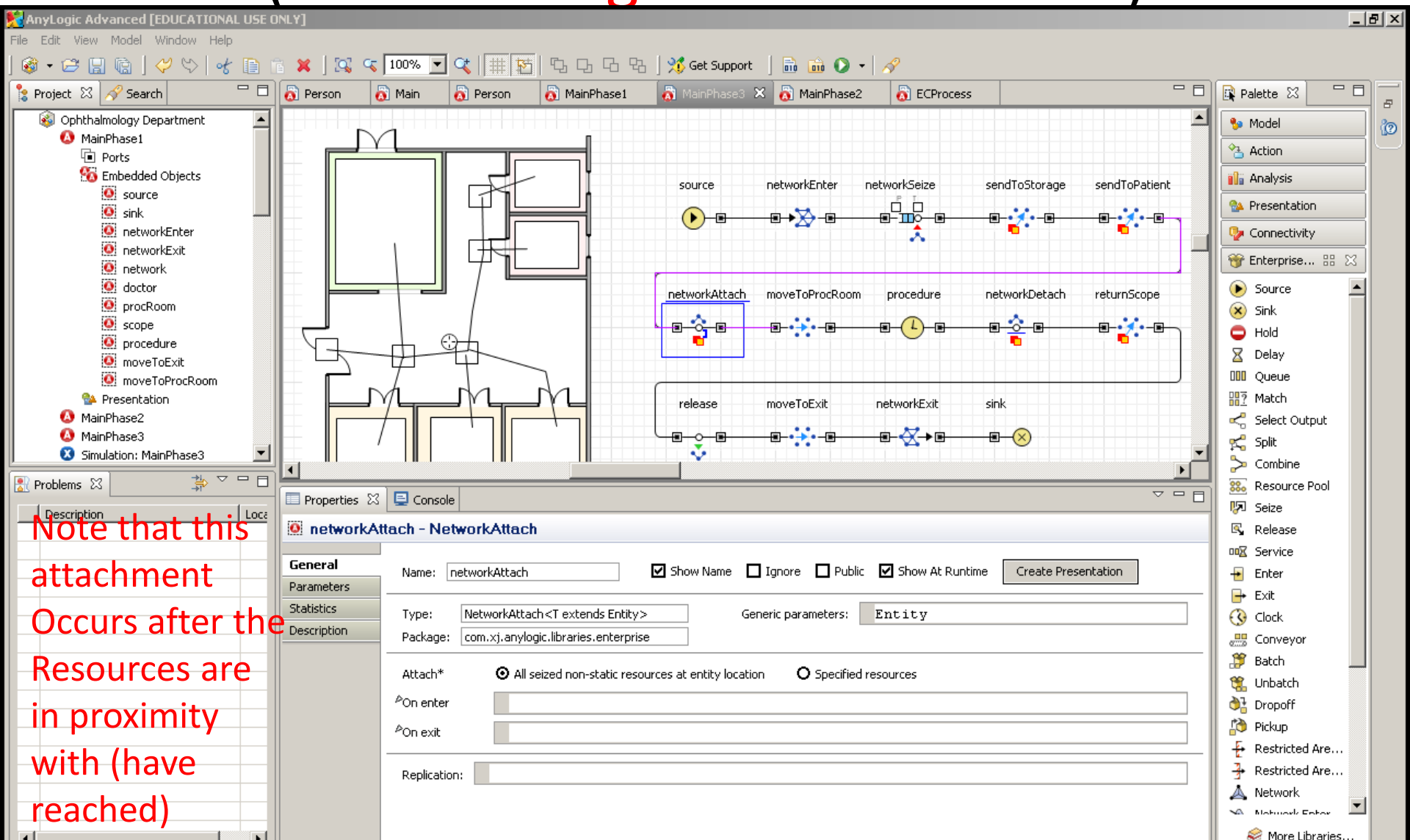
Network Send To: Moving a (Seized) Resource to a Resource, Entity, or Place



Example of Simultaneously Moving Multiple Resources Together via SendTo

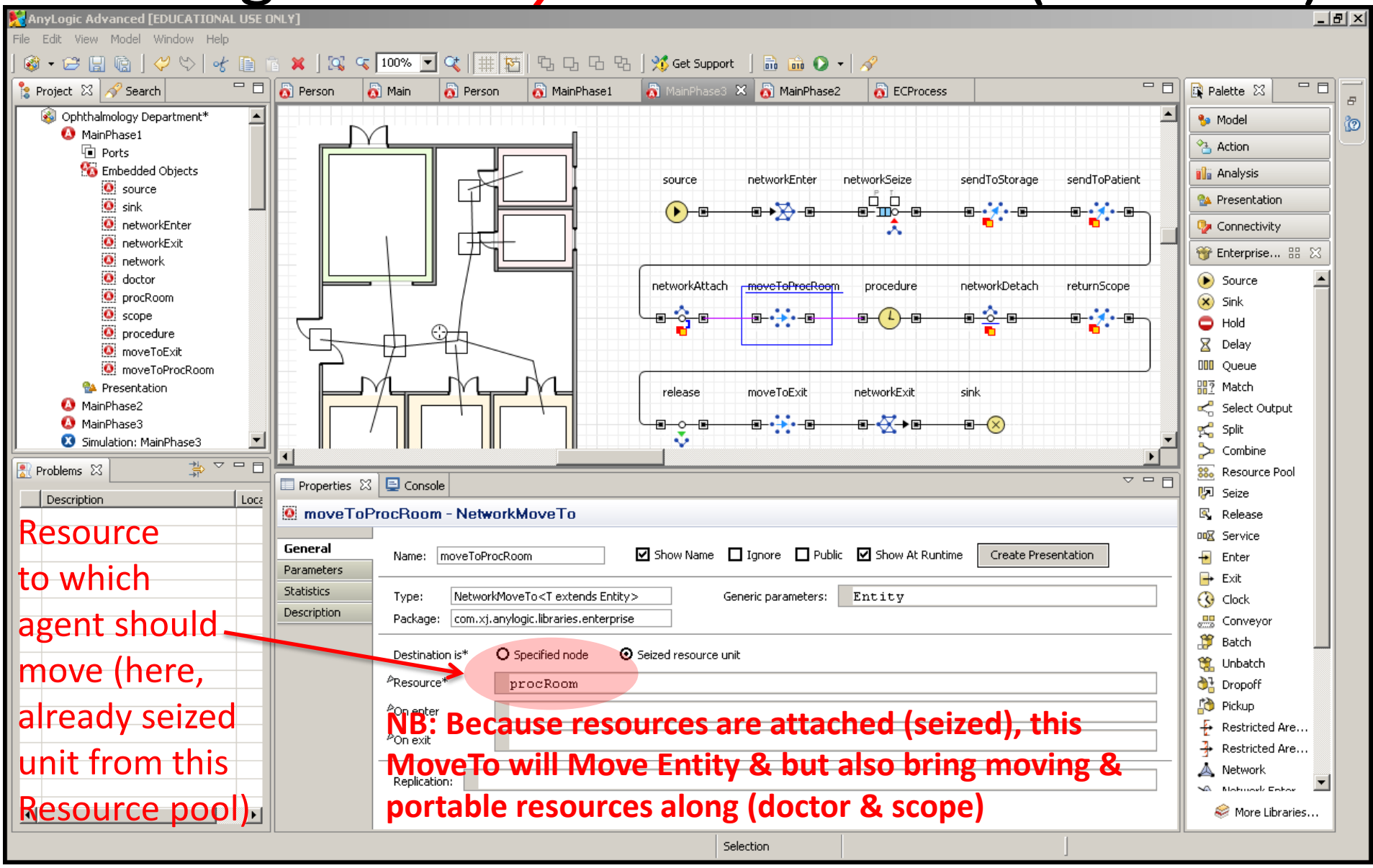


Network Attach: Associating Entity with Specified Seized Resources, or those Nearby (So move together henceforth)



Note that this attachment Occurs after the Resources are in proximity with (have reached)

Network Move To:
Moving an *Entity* to a Resource (or Node)

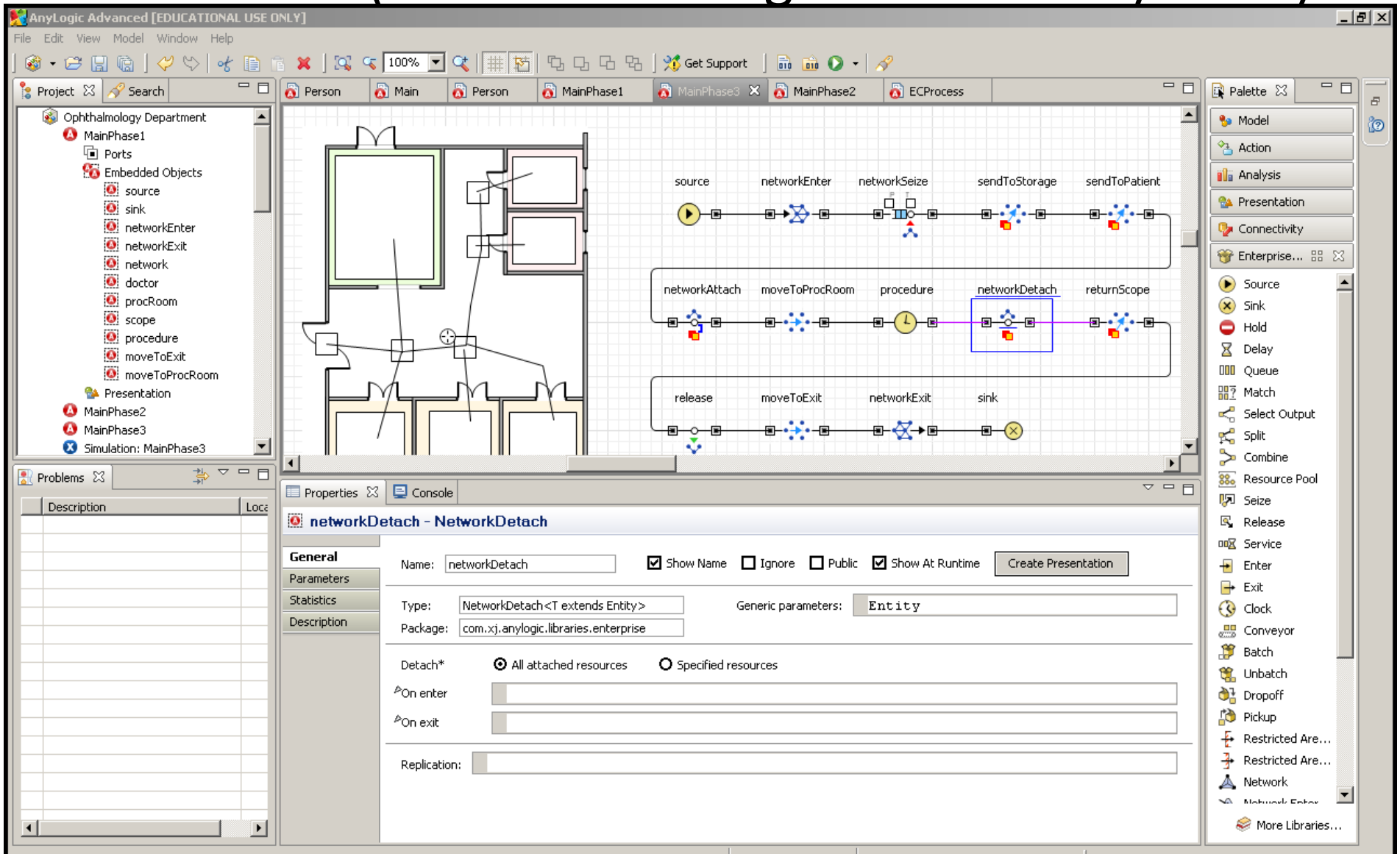


Resource to which agent should move (here, already seized unit from this Resource pool)

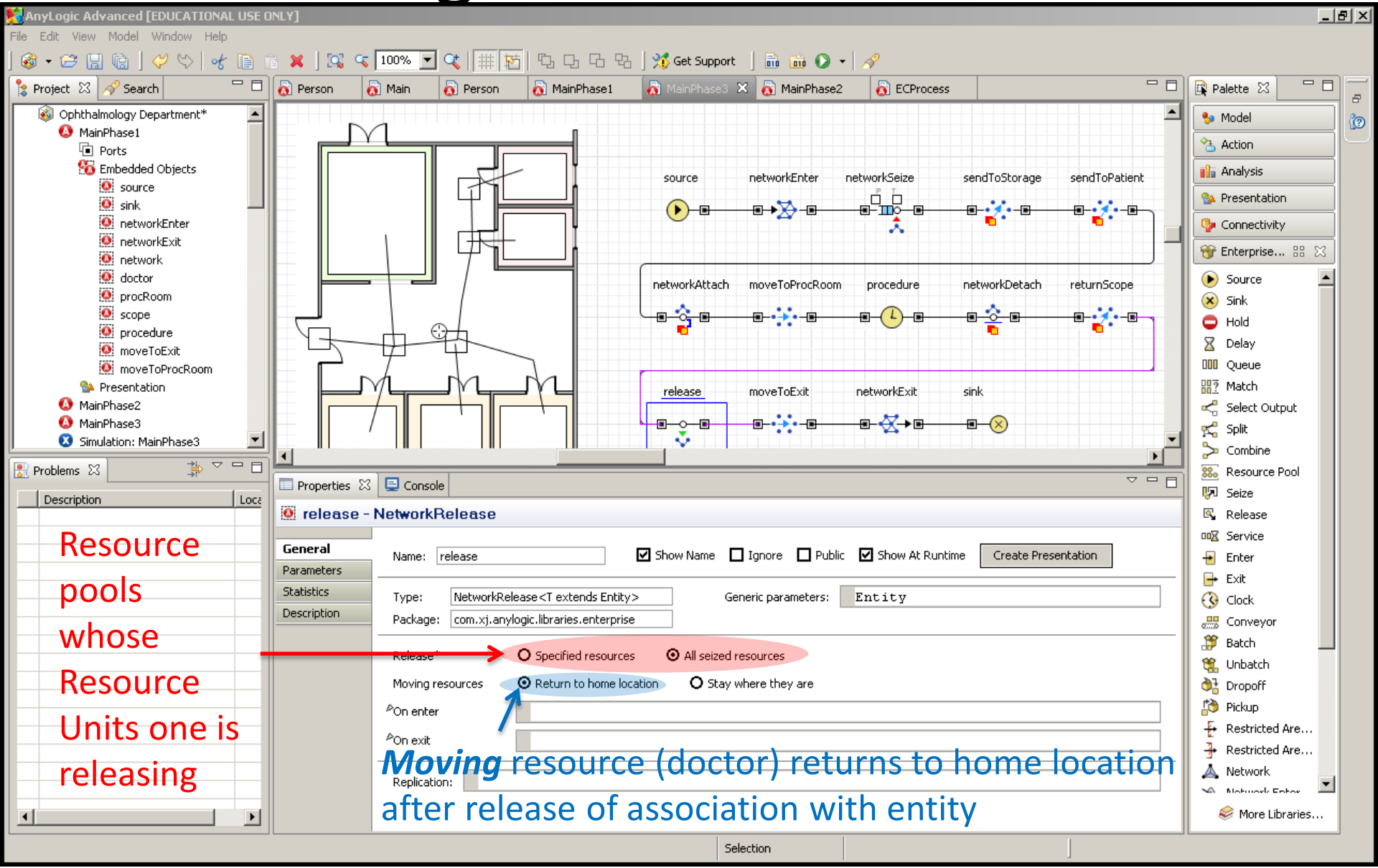
NB: Because resources are attached (seized), this MoveTo will Move Entity & but also bring moving & portable resources along (doctor & scope)

Network Detach

So entity can be physically Separated from resources (while remaining associated w/them)



Releasing Associated Resources



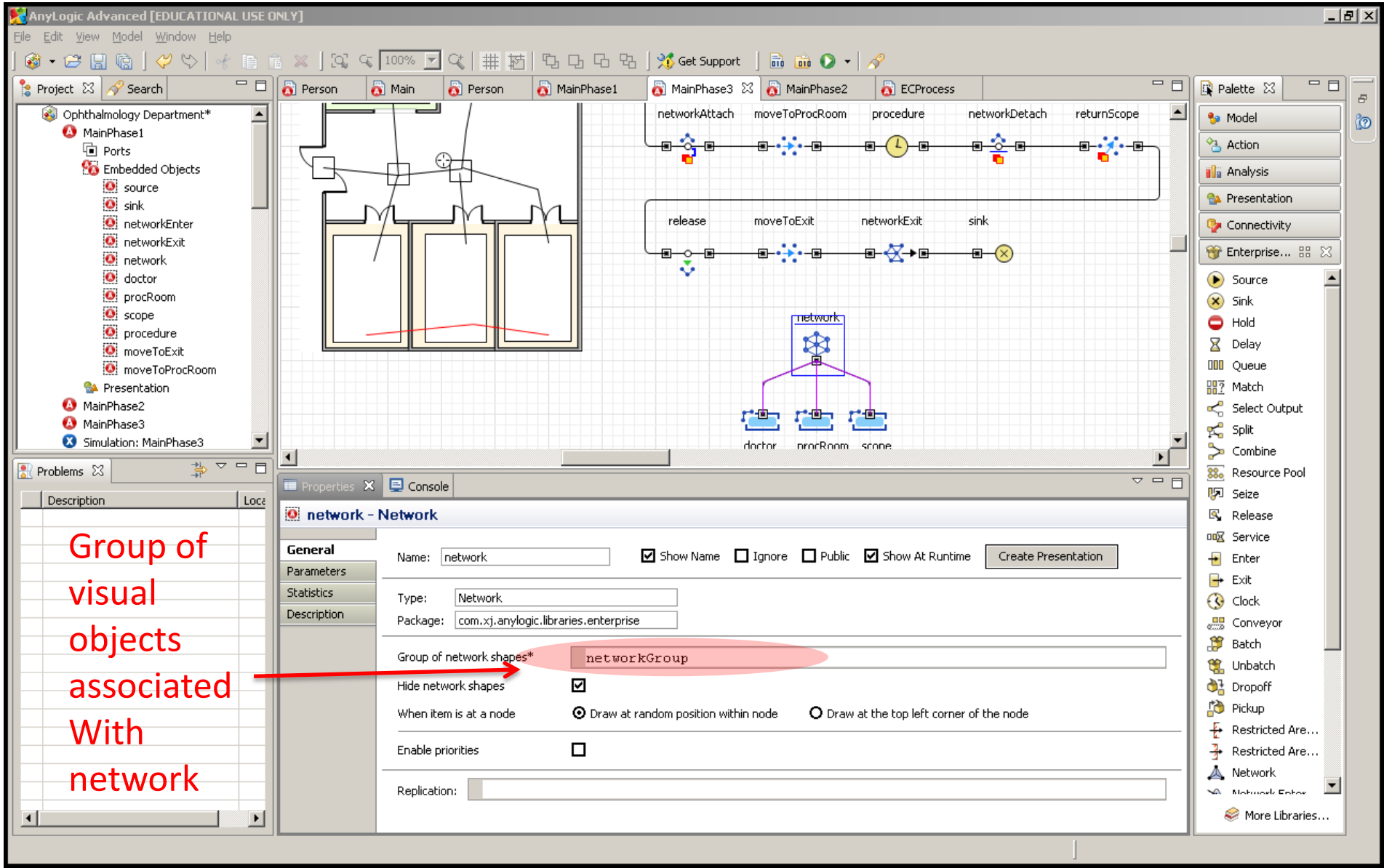
Resource pools whose Resource Units one is releasing

Moving resource (doctor) returns to home location after release of association with entity

Visual Depiction Accompanying Logical Flow

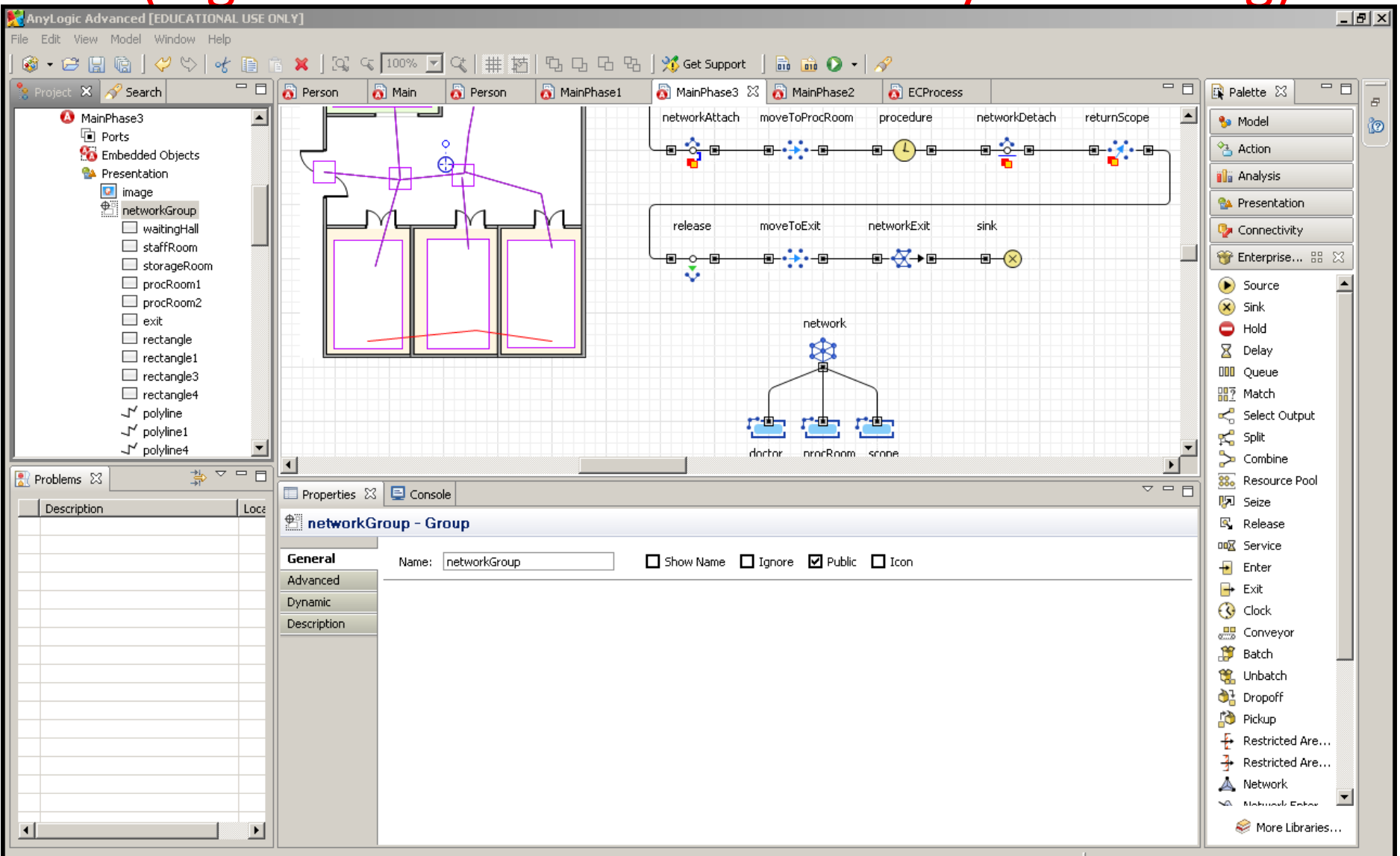
- Entities are associated with icons
- Resources are associated with
  - Locations
  - Icons
- Movement networks are associated with routing paths
  - Often want to move resources or icons among different visual locations
    - Specific points (e.g. a storage closet for mobile resources)
    - Points associated with fixed resources (e.g. a MRI scanner)

Association of Network with Paths

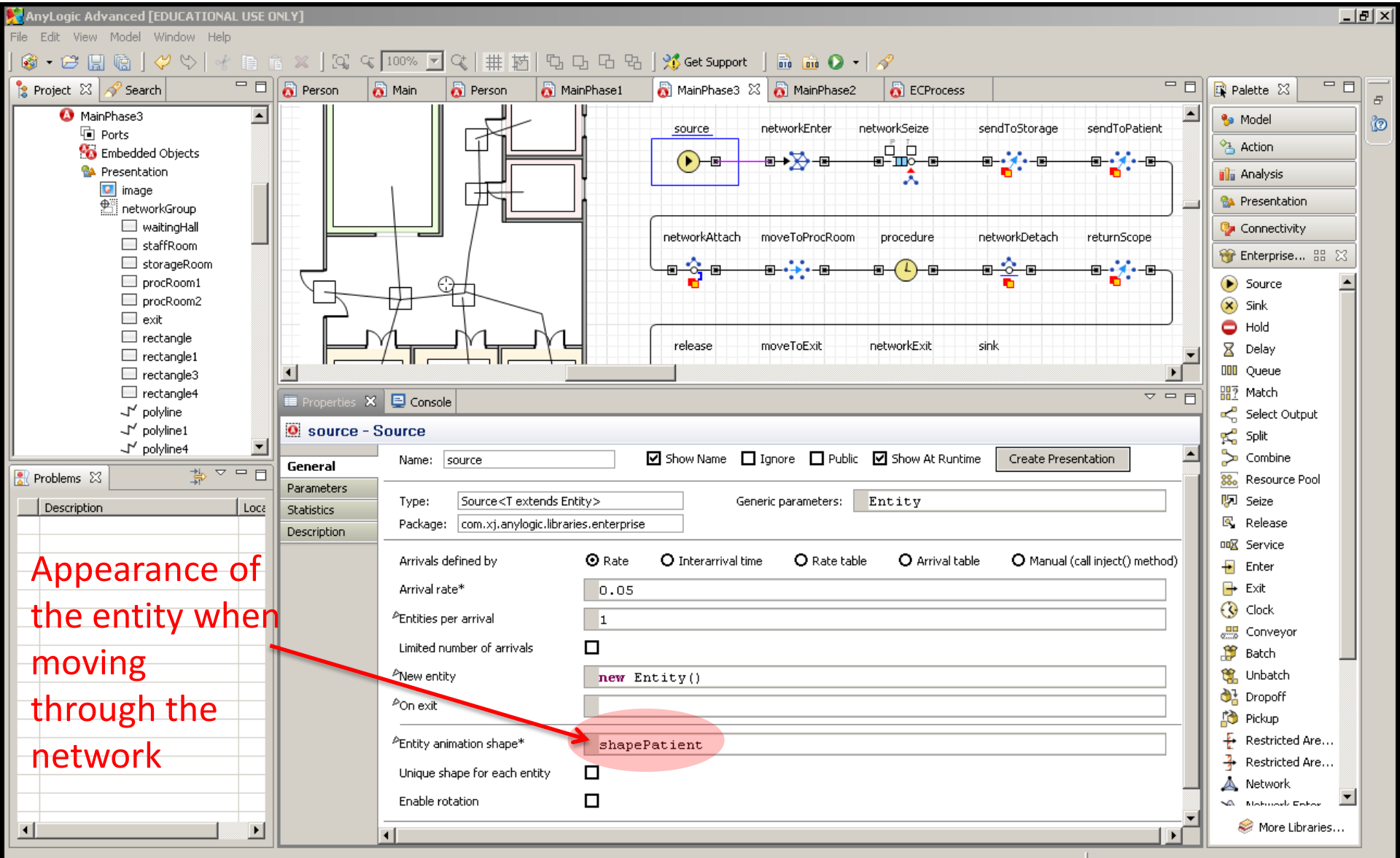


Associated Presentation “Group”

The network will “know” about these (e.g. location & interconnectivity for routing)

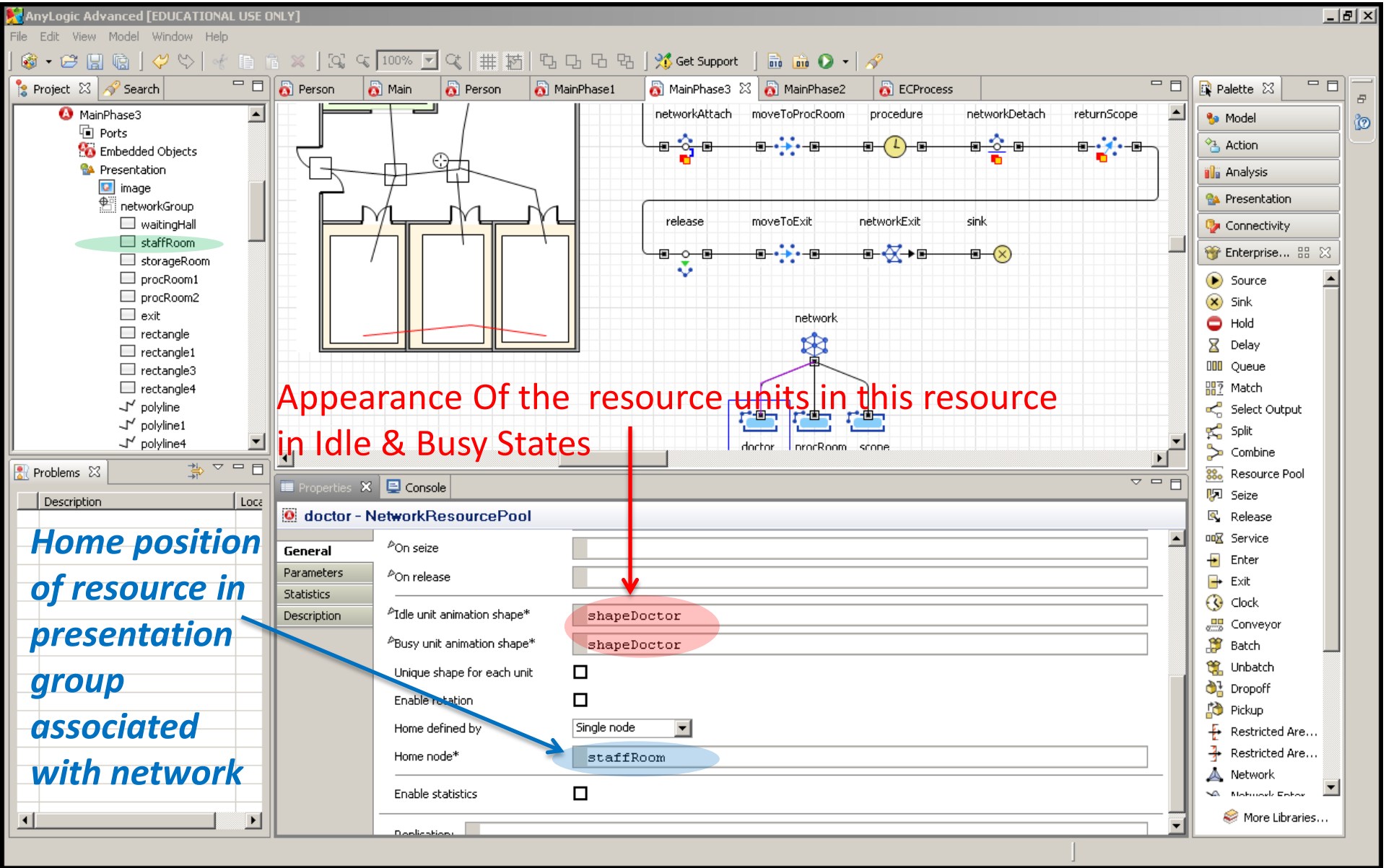


Presentation of Entity

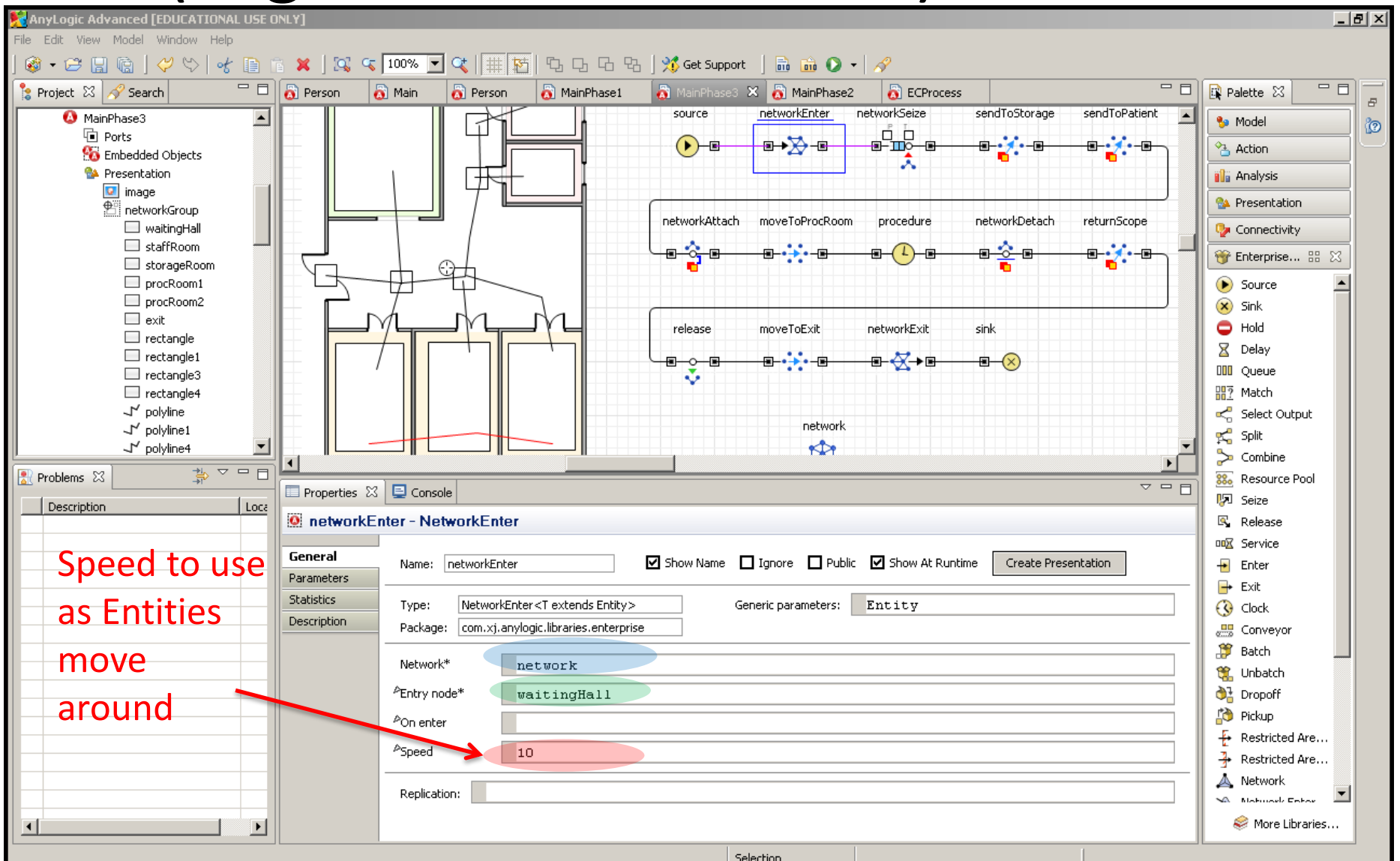


Appearance of the entity when moving through the network

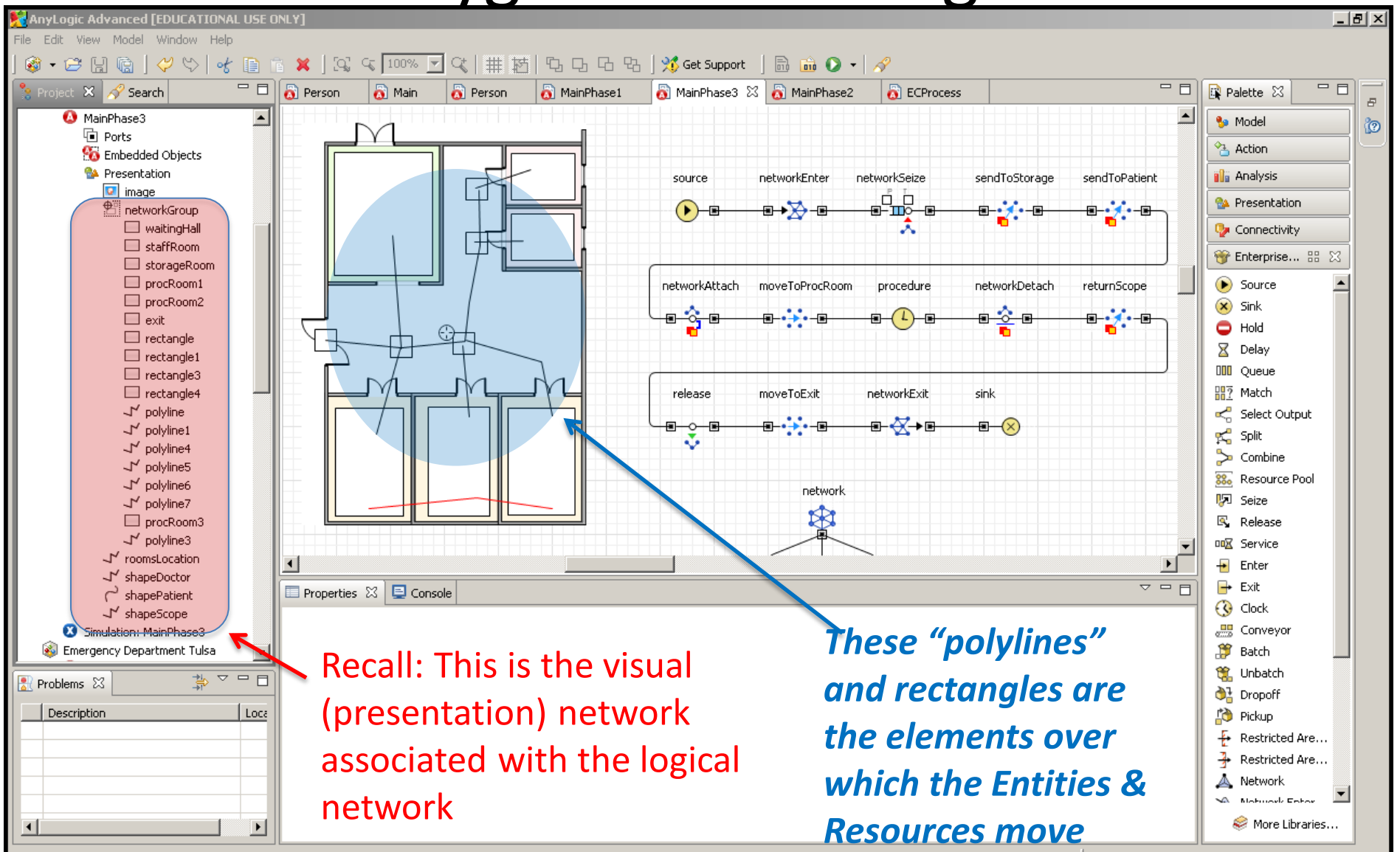
Presentation Properties of a Resource



Entering the Network: Where & with What (Logical & Presentation) Network



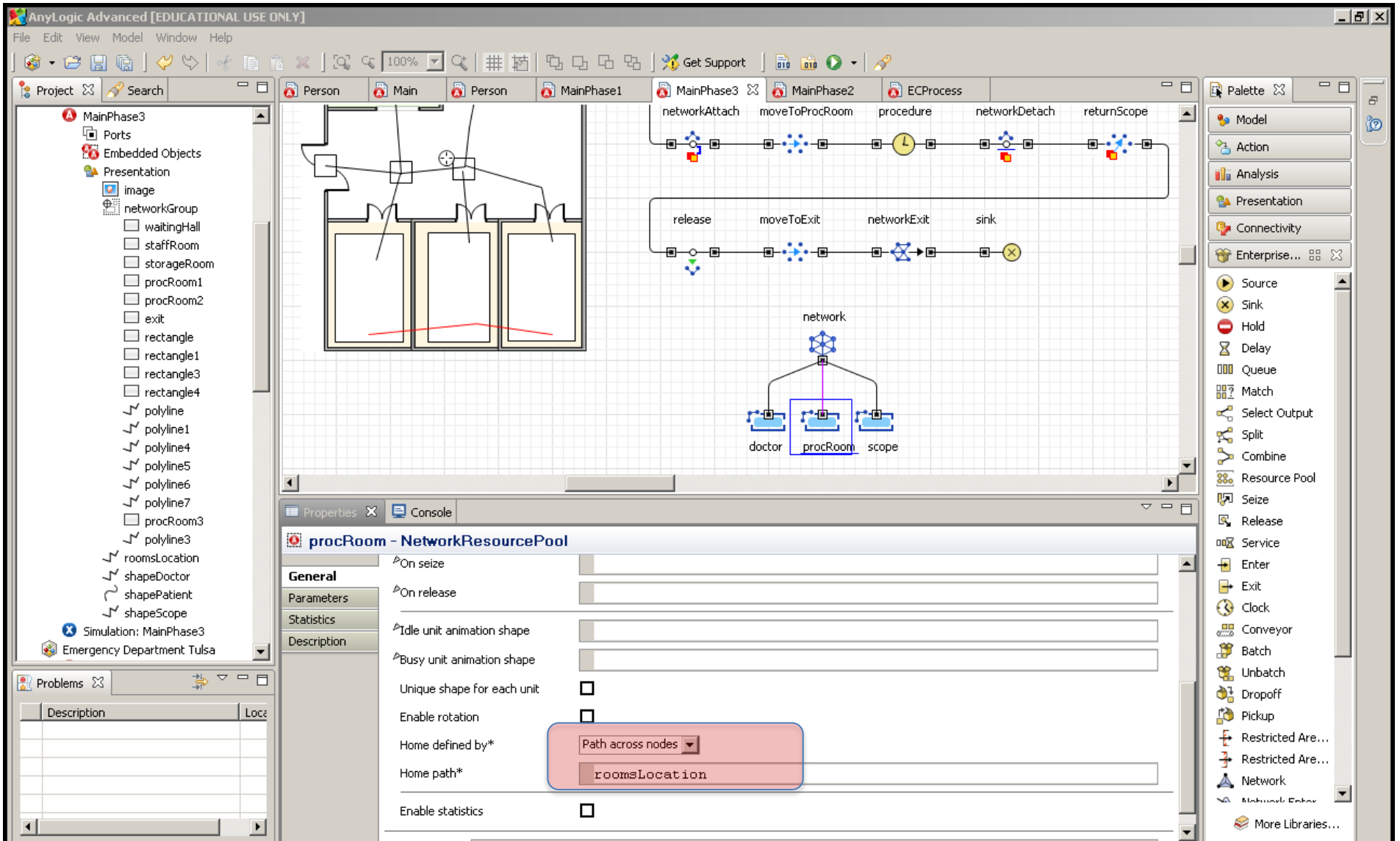
Movement Network: Defined by Polygons & Rectangles



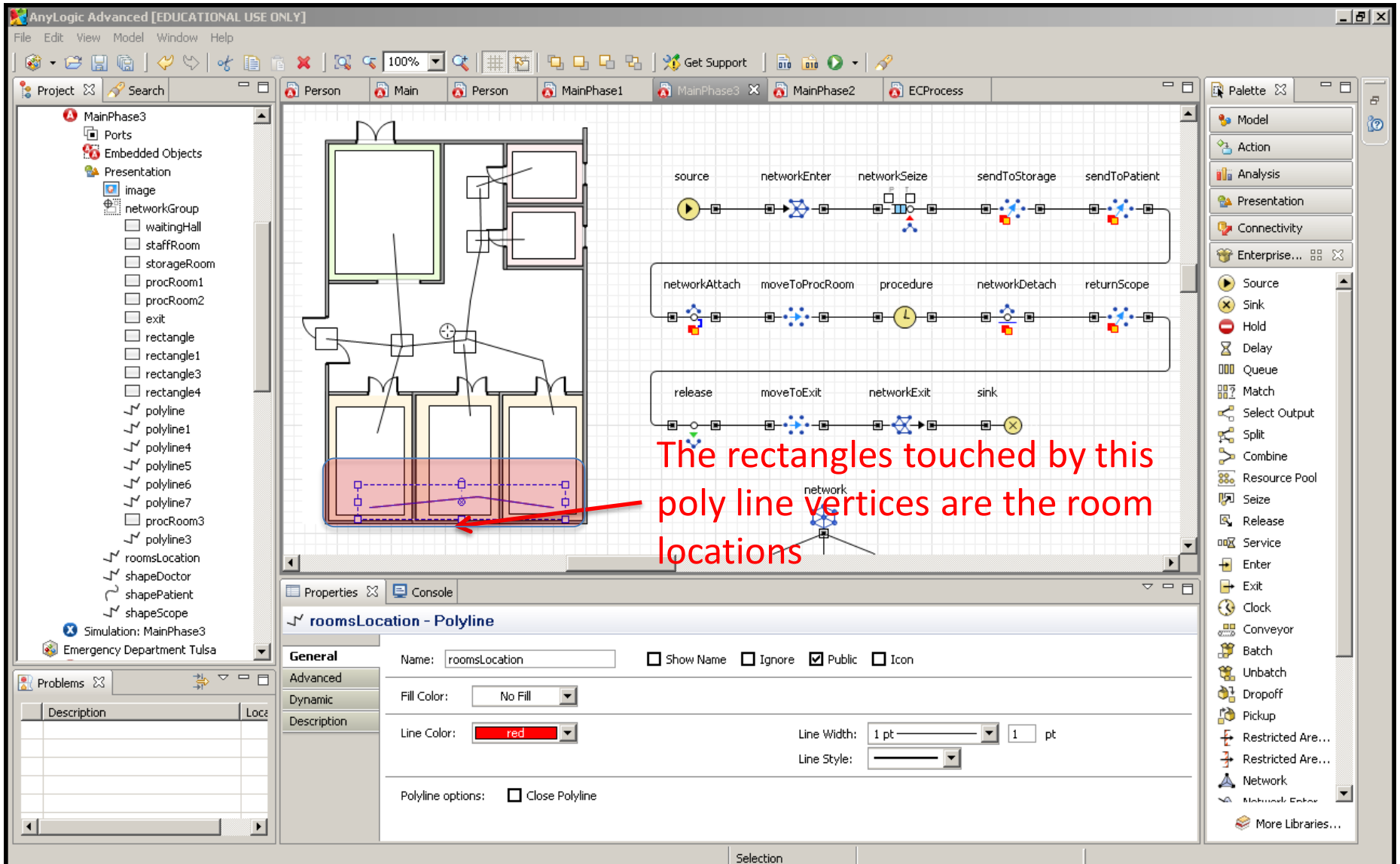
Recall: This is the visual (presentation) network associated with the logical network

These "polylines" and rectangles are the elements over which the Entities & Resources move

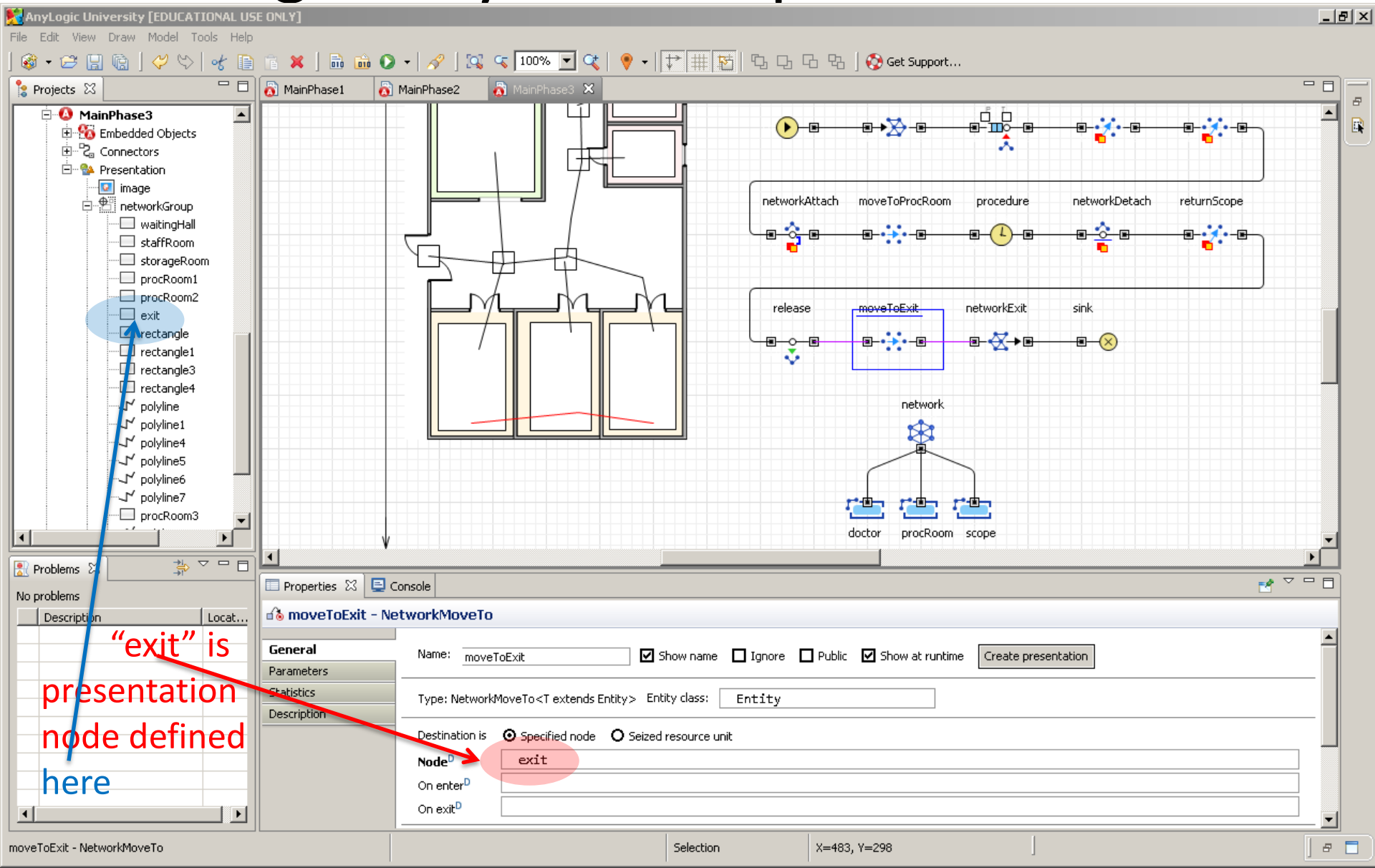
Recall: The Location of Room Resource Pool is given as being "Path across nodes" defined by the Polyline



Polyline Describes the Location of the Procedure Rooms



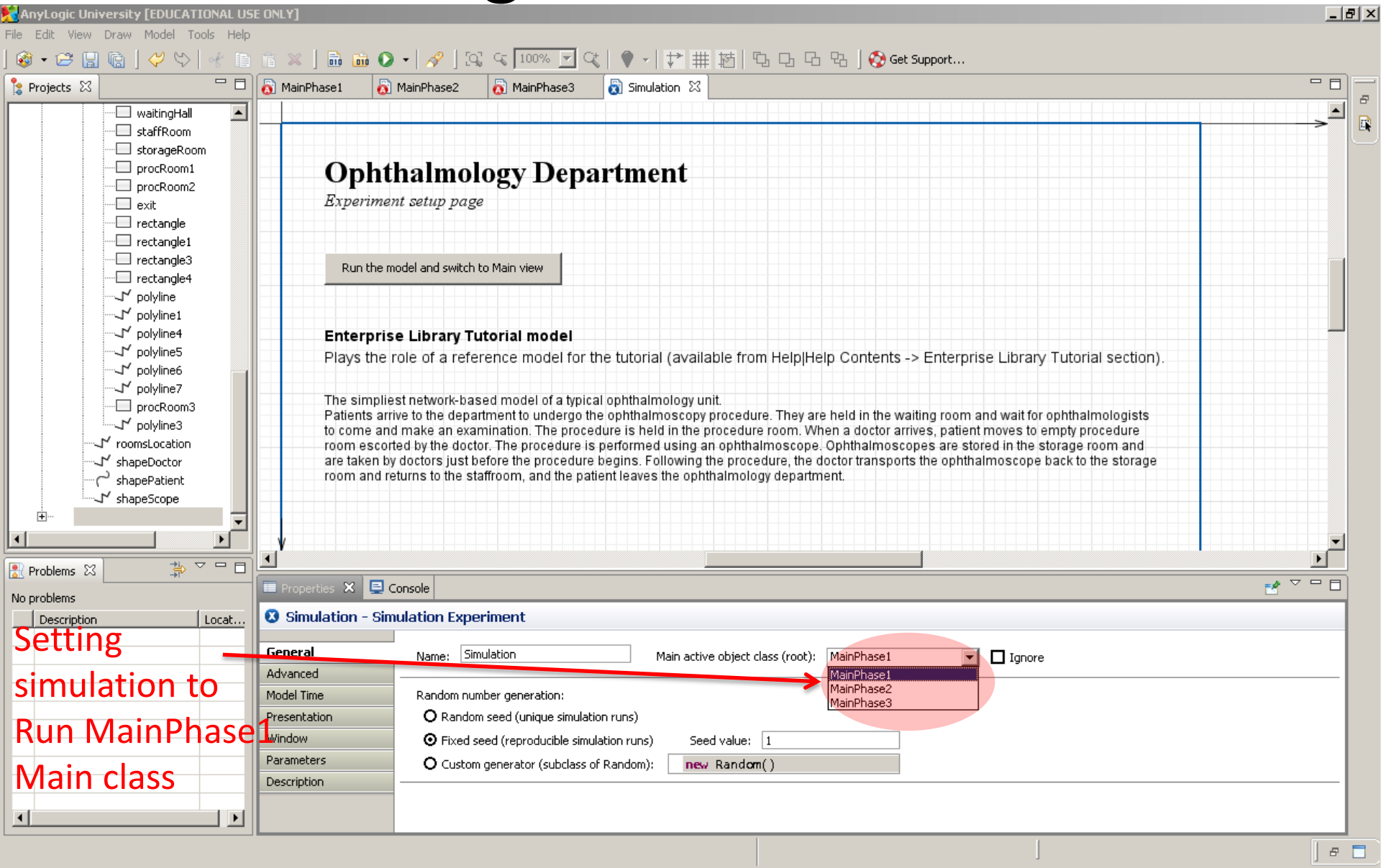
Moving Entity to an Explicit Visual Point



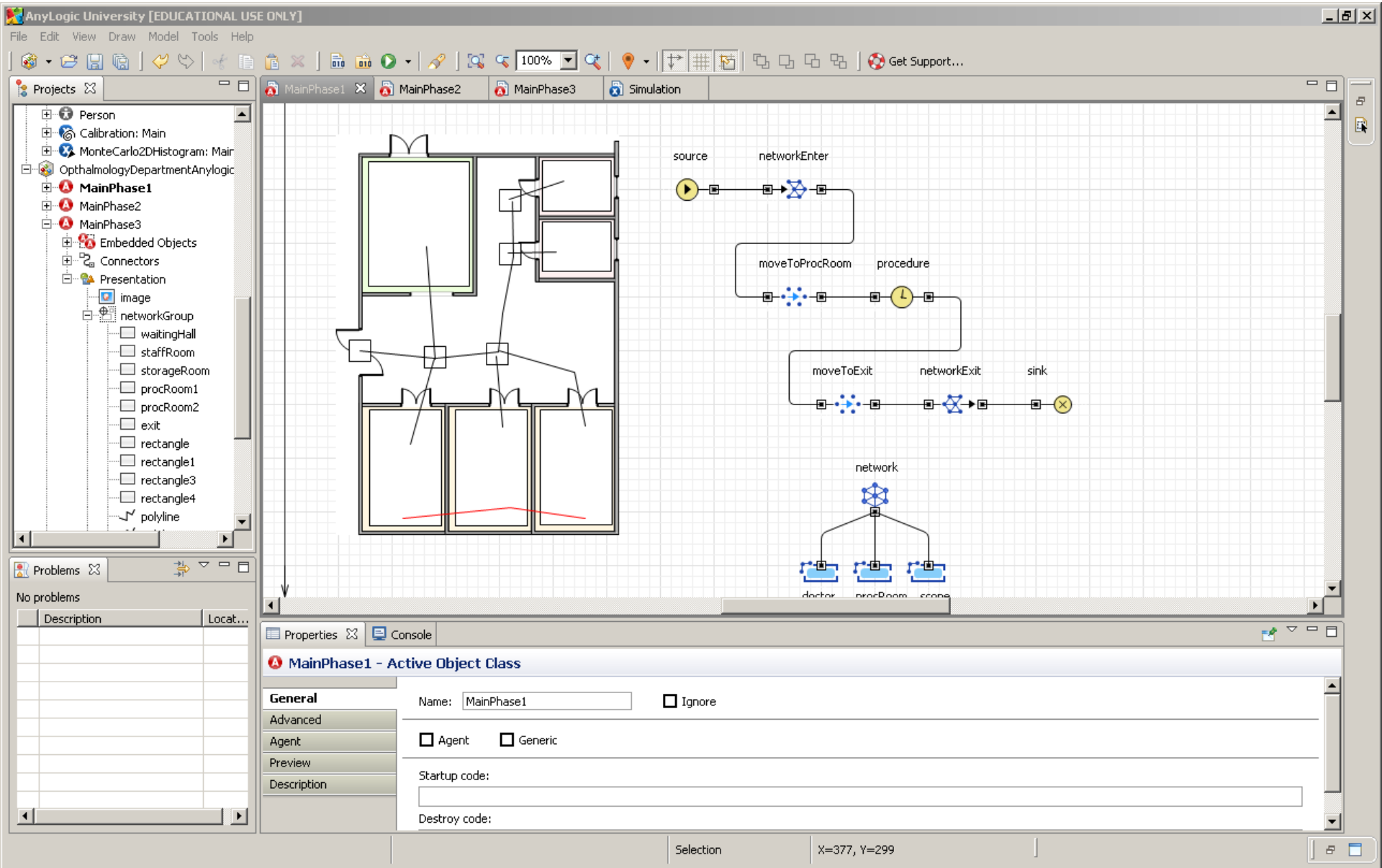
Subclassing: A Valuable Tool

- So as to customized the desired system behavior, it can be useful to customize entities & resources (resource units)
  - To e.g. carry around additional information (e.g. associated external agent in agent-based model, history information, etc.)
  - Particular specialized network types
- Because the original entities & resource units are classes, this can be accomplished via subclassing (subclass Entity & ResourceUnit)
- If do this, parameterize generics by subclass type S (e.g. NetworkResourcePool<S>)
- We will be discussing subclassing in an upcoming Java tutorial

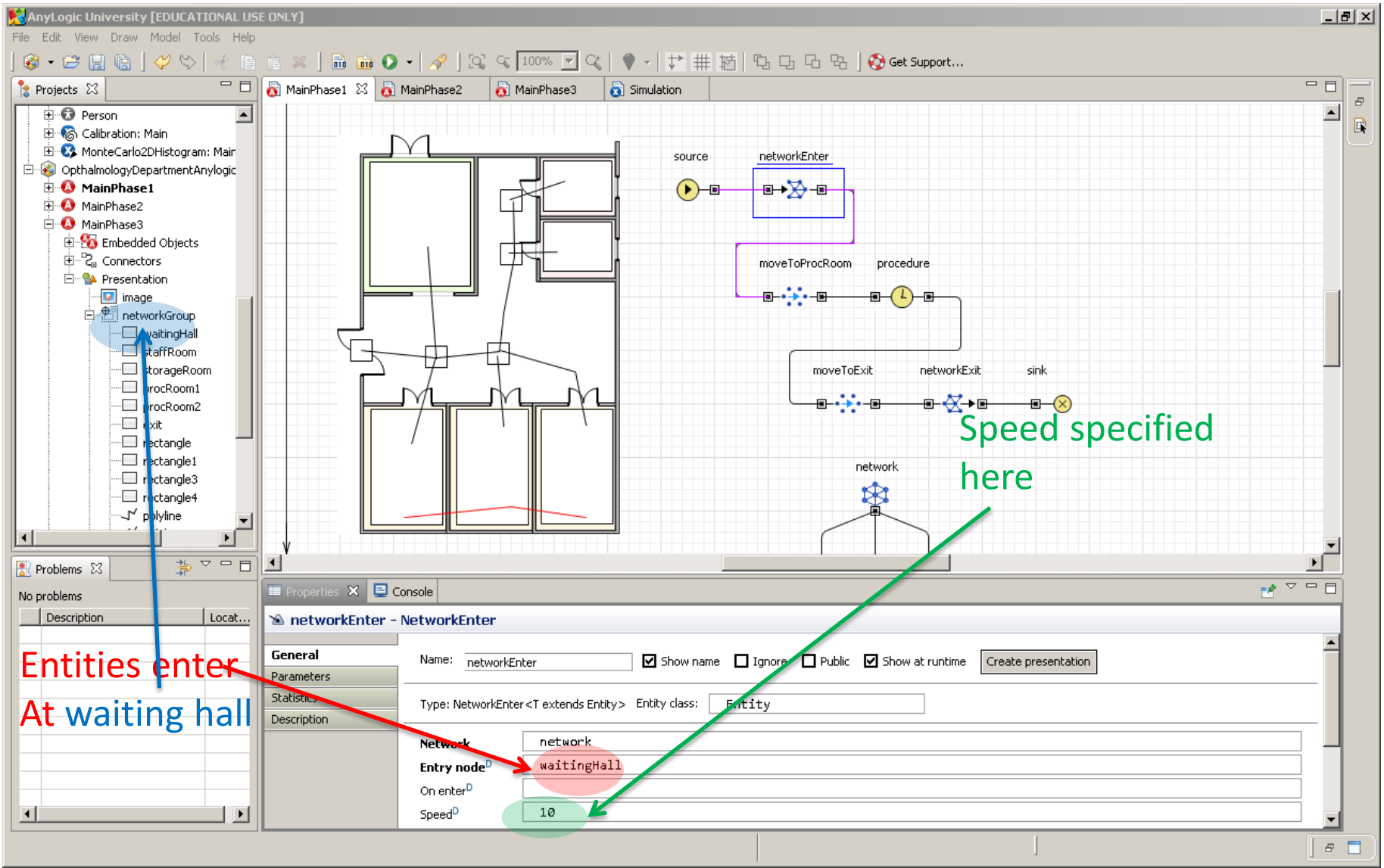
Understanding the Model: MainPhase1



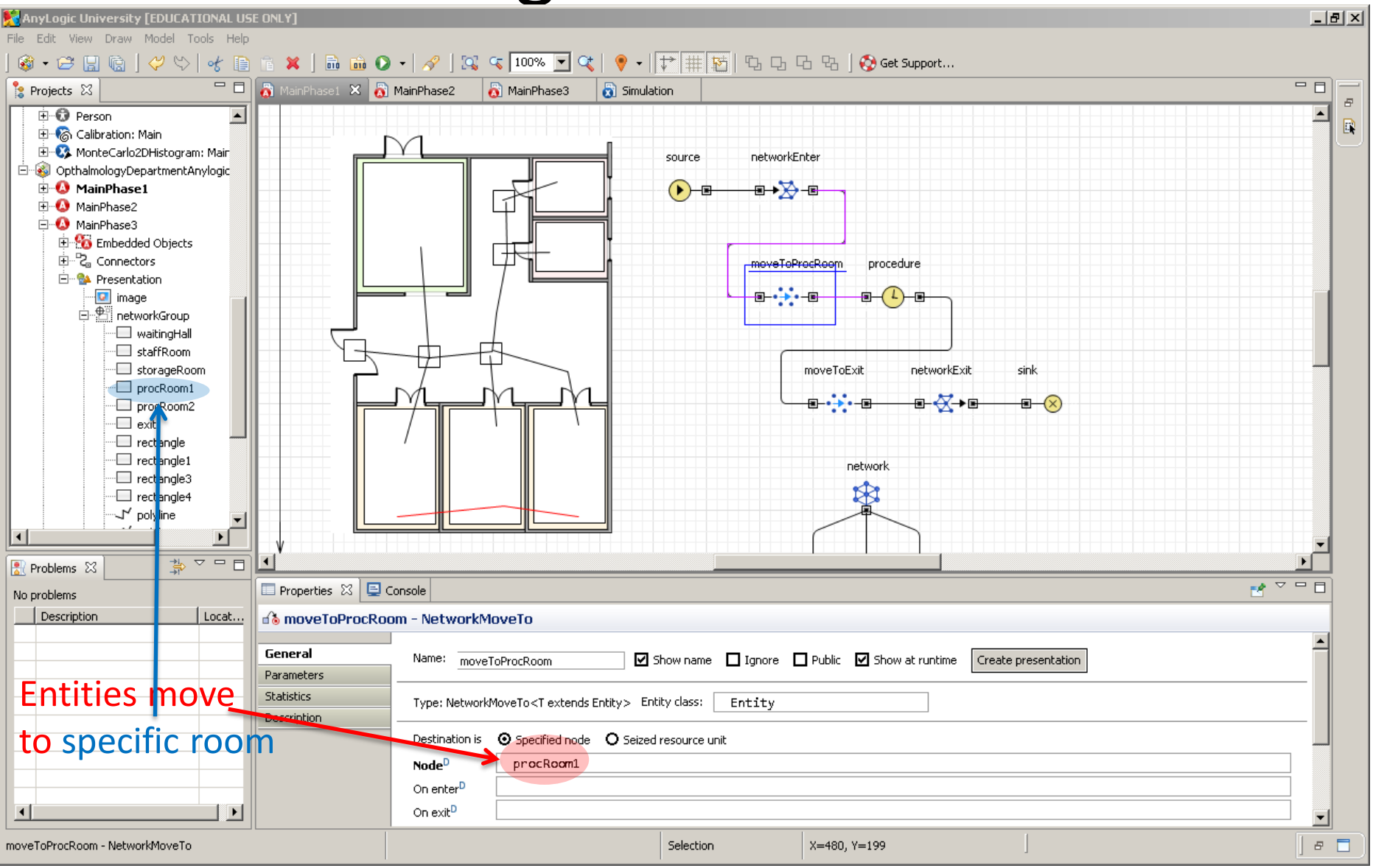
No Resource Constraints



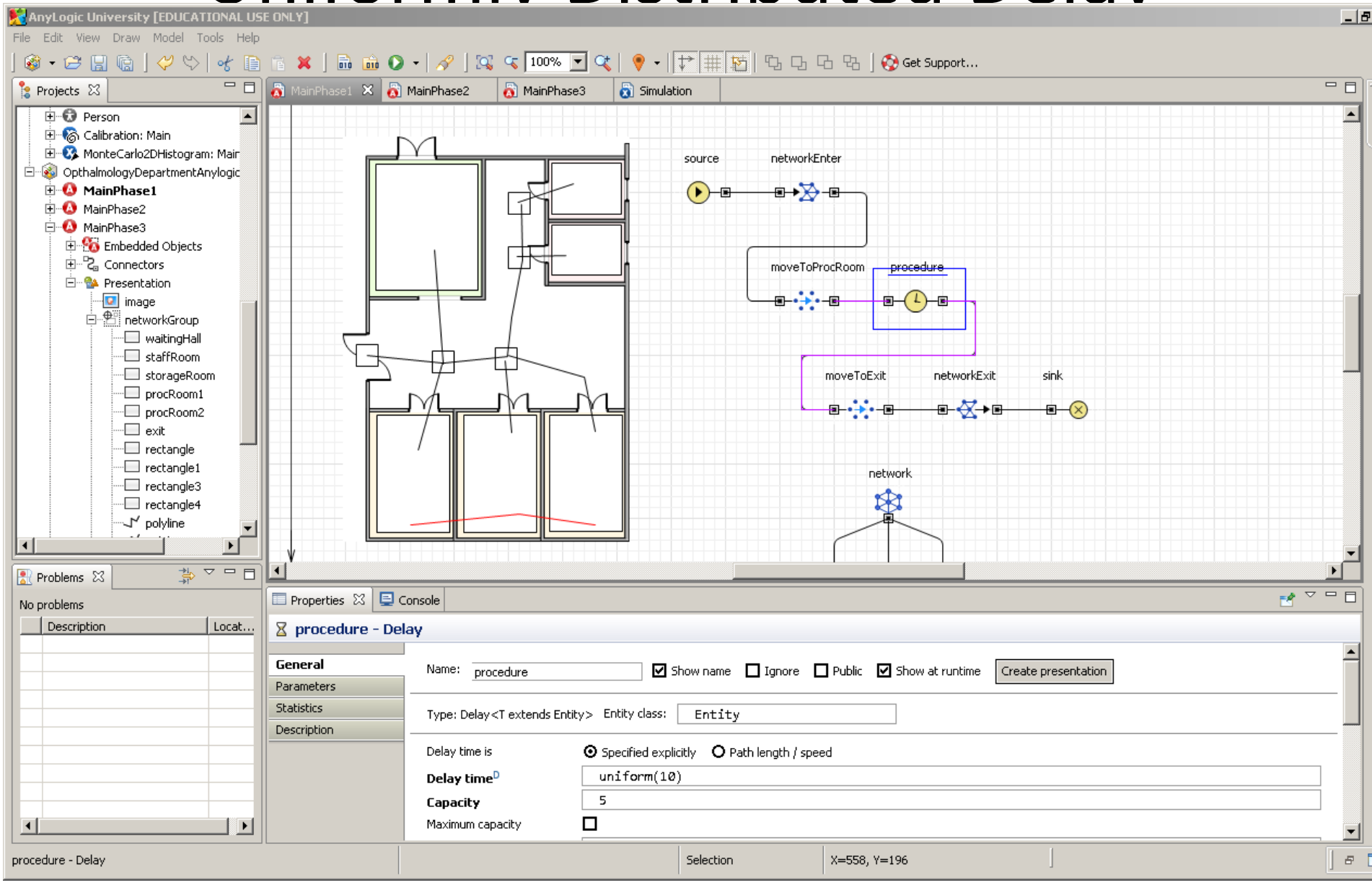
Entering the Network



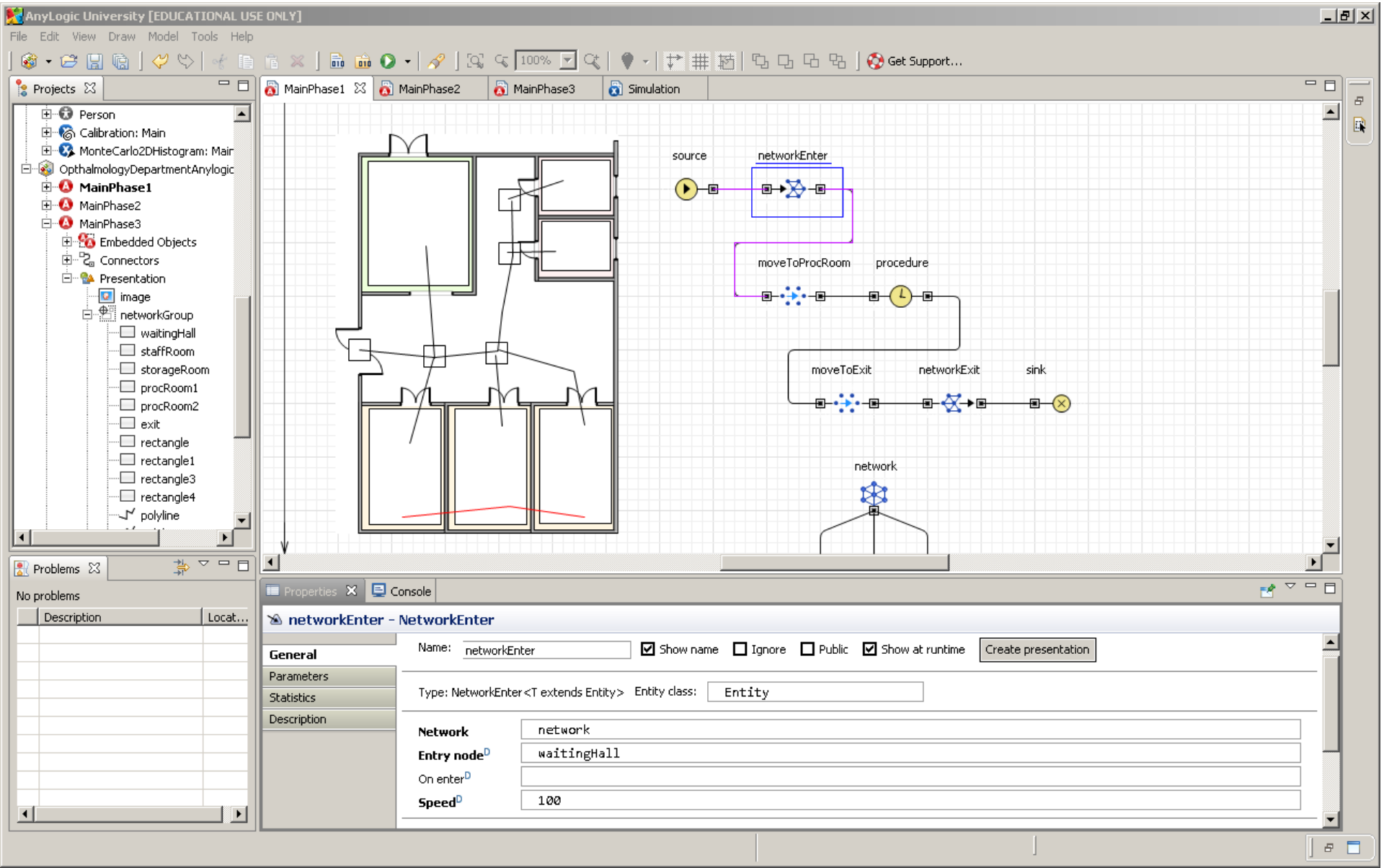
Moving to a Fixed Node



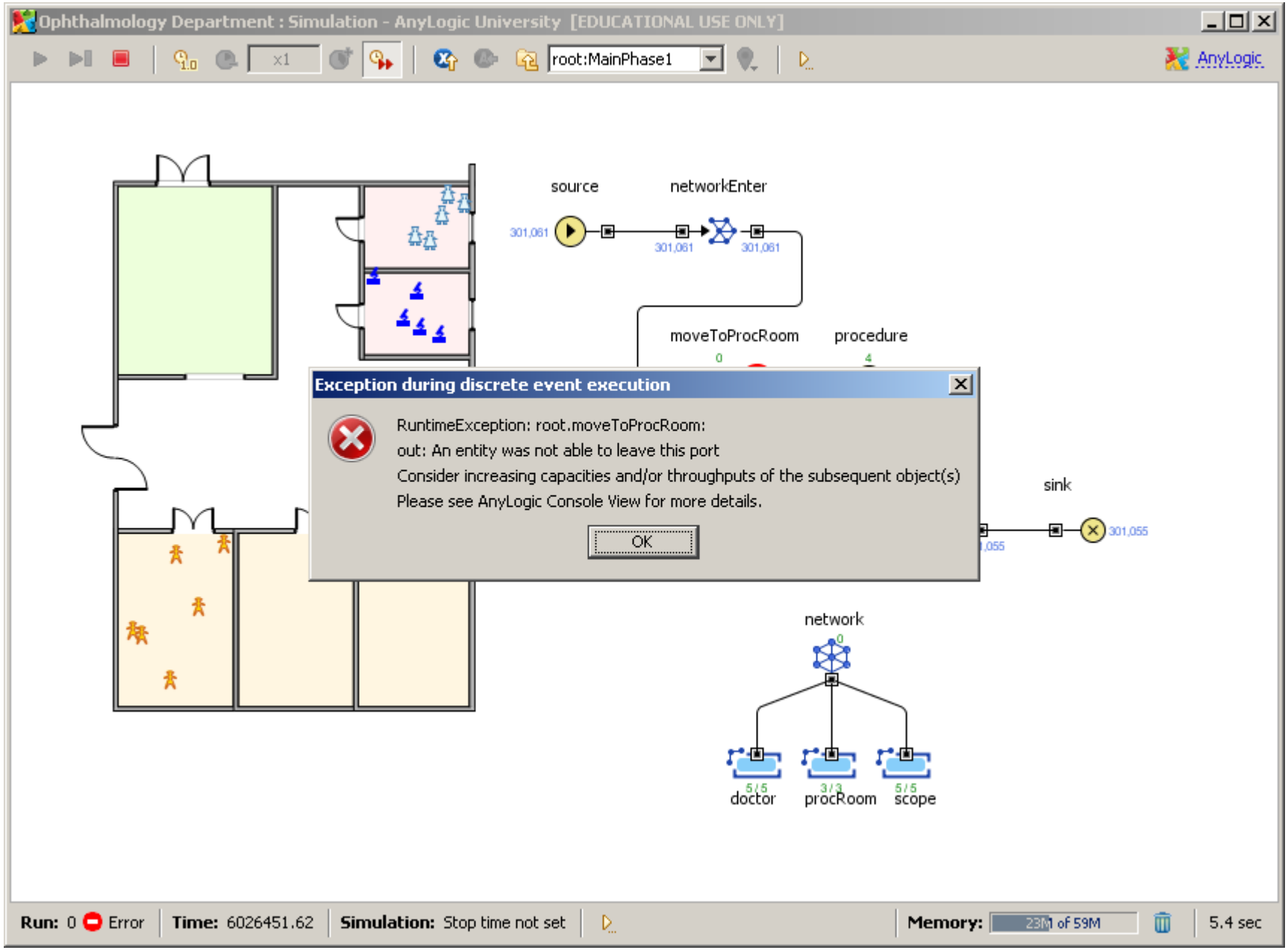
Uniformly Distributed Delay



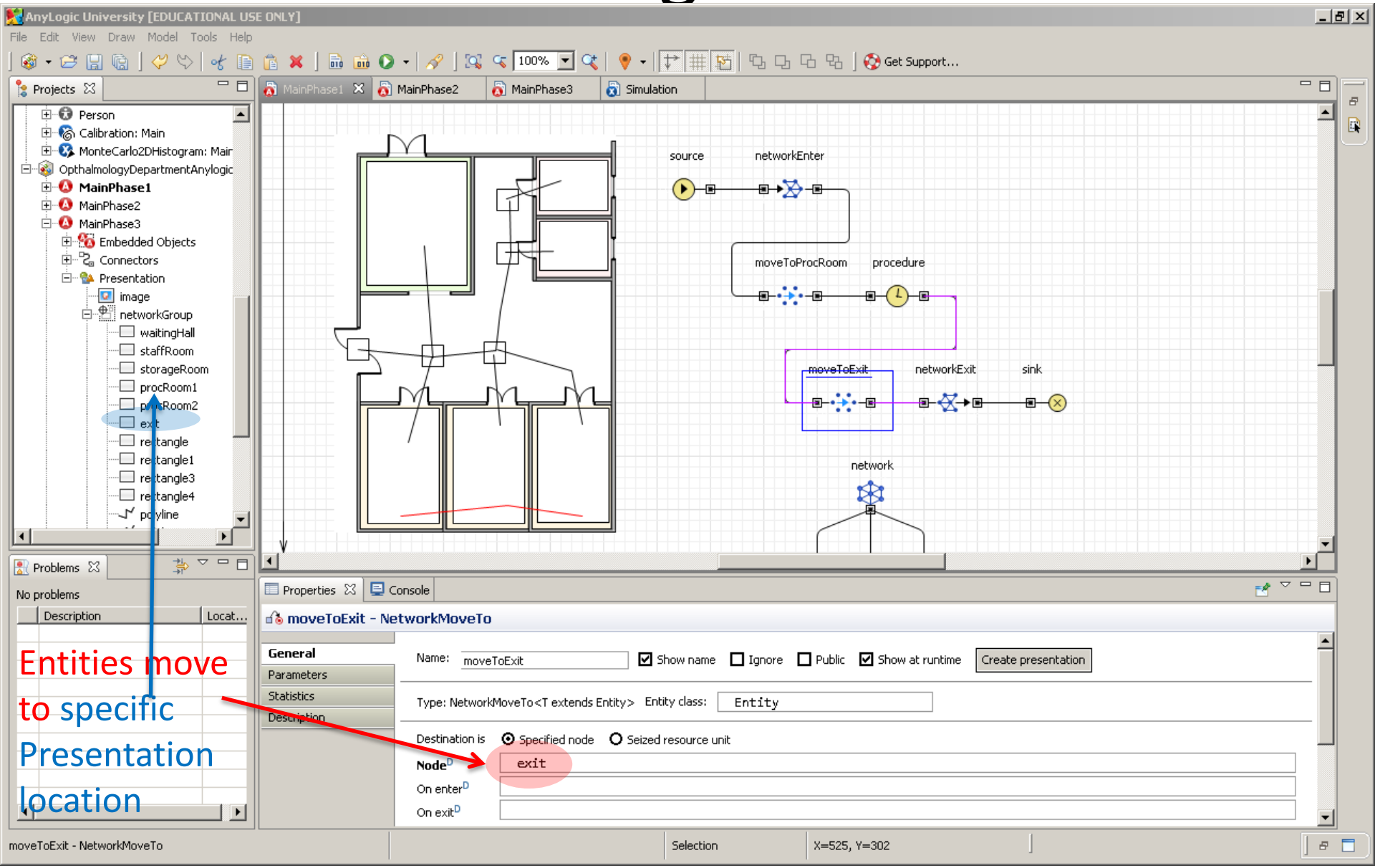
To see Capacity Limitation, Increase Speed



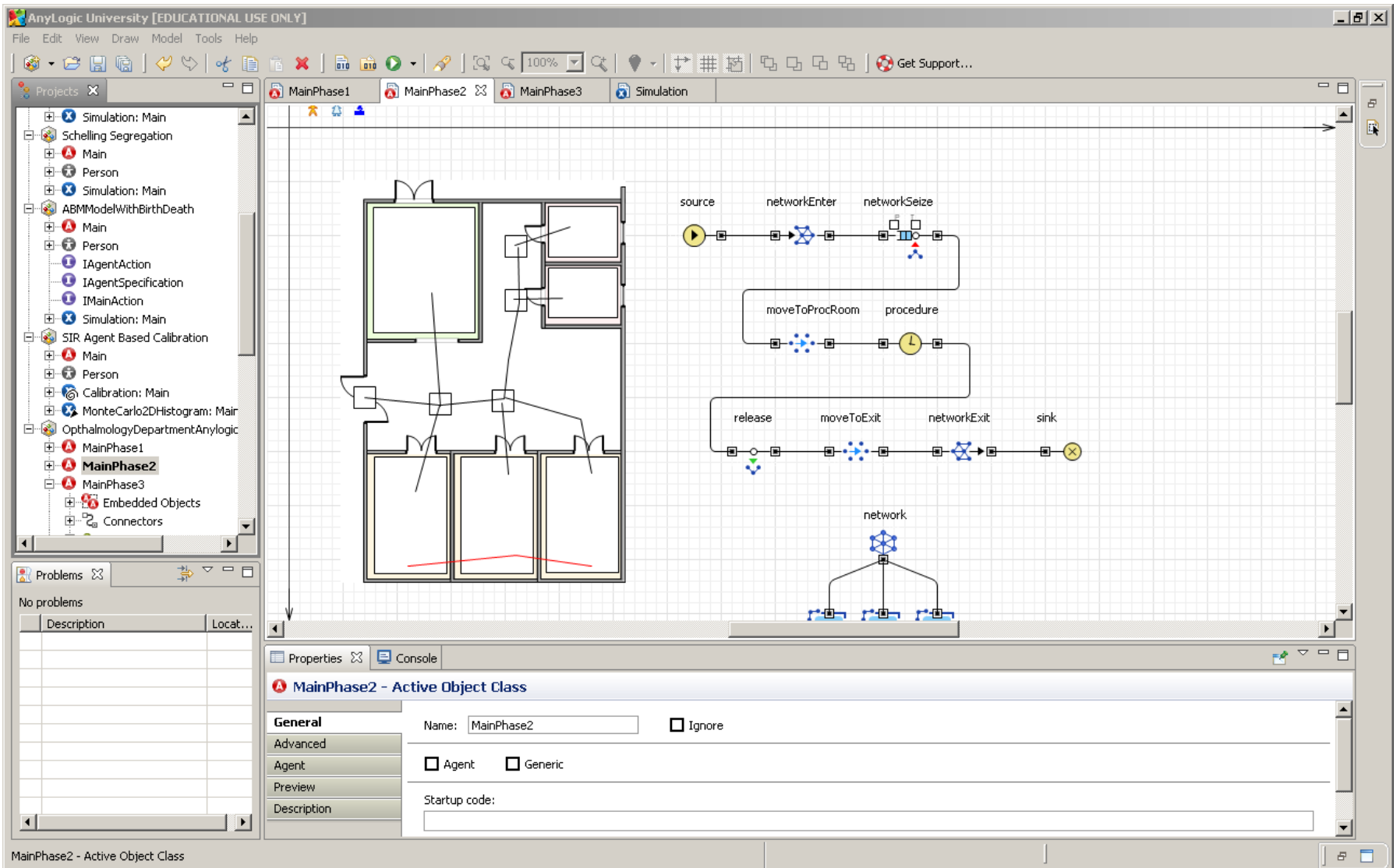
Limited Capacity



Moving to Exit



Phase 2


AnyLogic University [EDUCATIONAL USE ONLY]
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Projects
Simulation: Main
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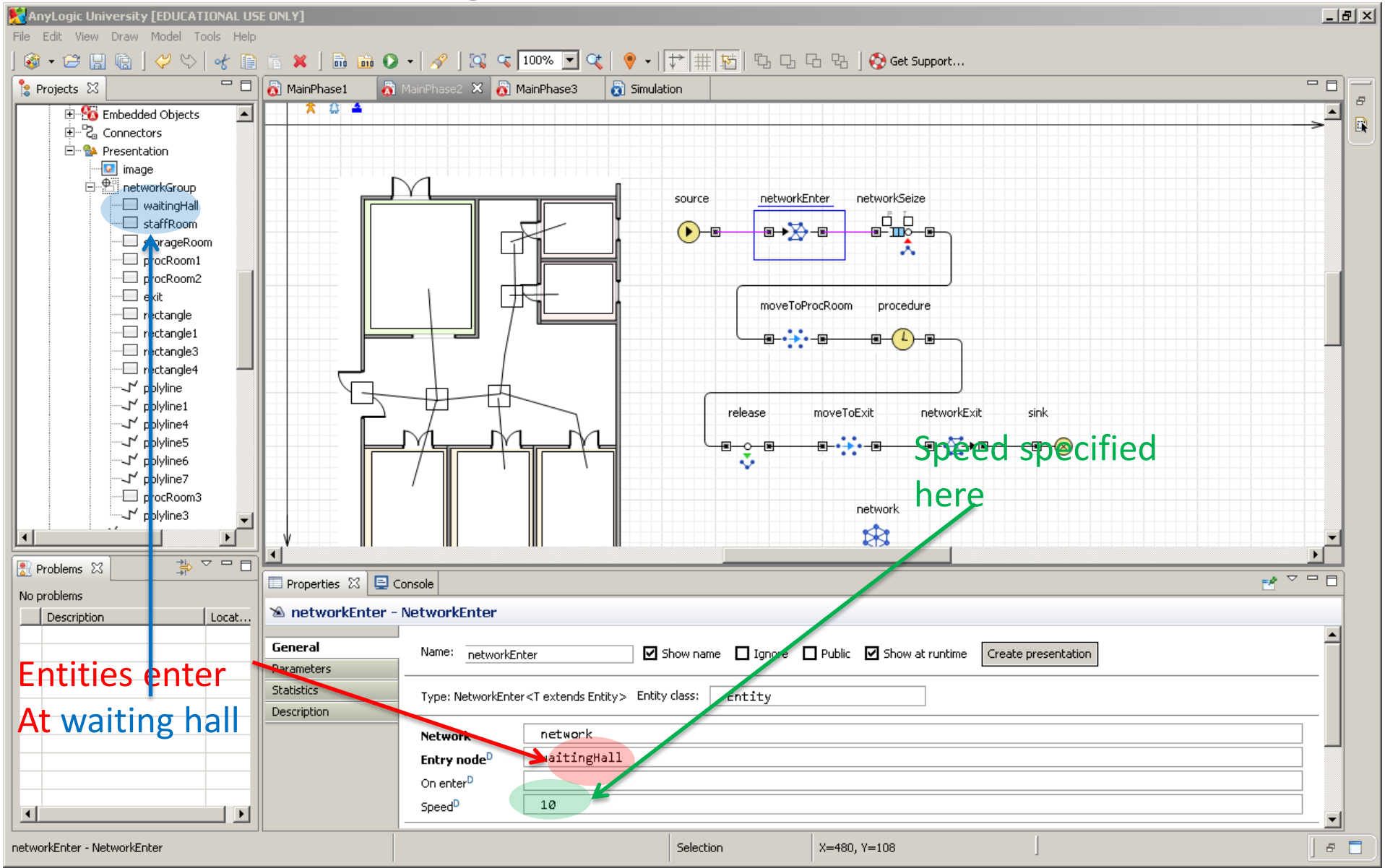
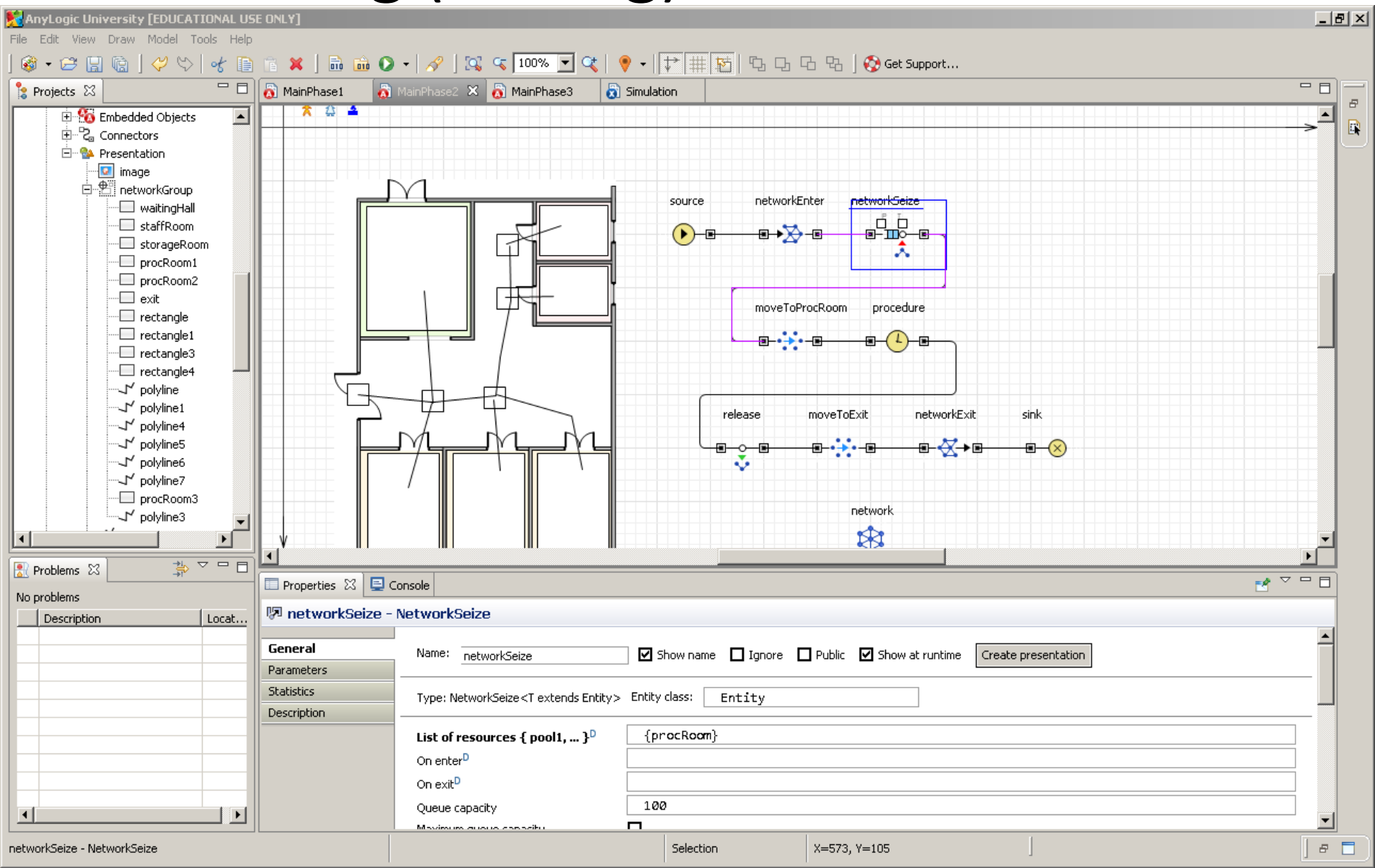
Person
Simulation: Main
ABMModelWithBirthDeath
Main
Person
IAgentAction
IAgentSpecification
IMainAction
Simulation: Main
SIR Agent Based Calibration
Main
Person
Calibration: Main
MonteCarlo2DHistogram: Mair
OpthalmologyDepartmentAnylogic
MainPhase1
MainPhase2
MainPhase3
Embedded Objects
Connectors
MainPhase1
MainPhase2
MainPhase3
Simulation
source
networkEnter
networkSeize
moveToProcRoom
procedure
release
moveToExit
networkExit
sink
network
Problems
No problems
Description
Locat...
Properties
Console
MainPhase2 - Active Object Class
General
Advanced
Agent
Preview
Description
Name: MainPhase2
Ignore
Agent
Generic
Startup code:
MainPhase2 - Active Object Class

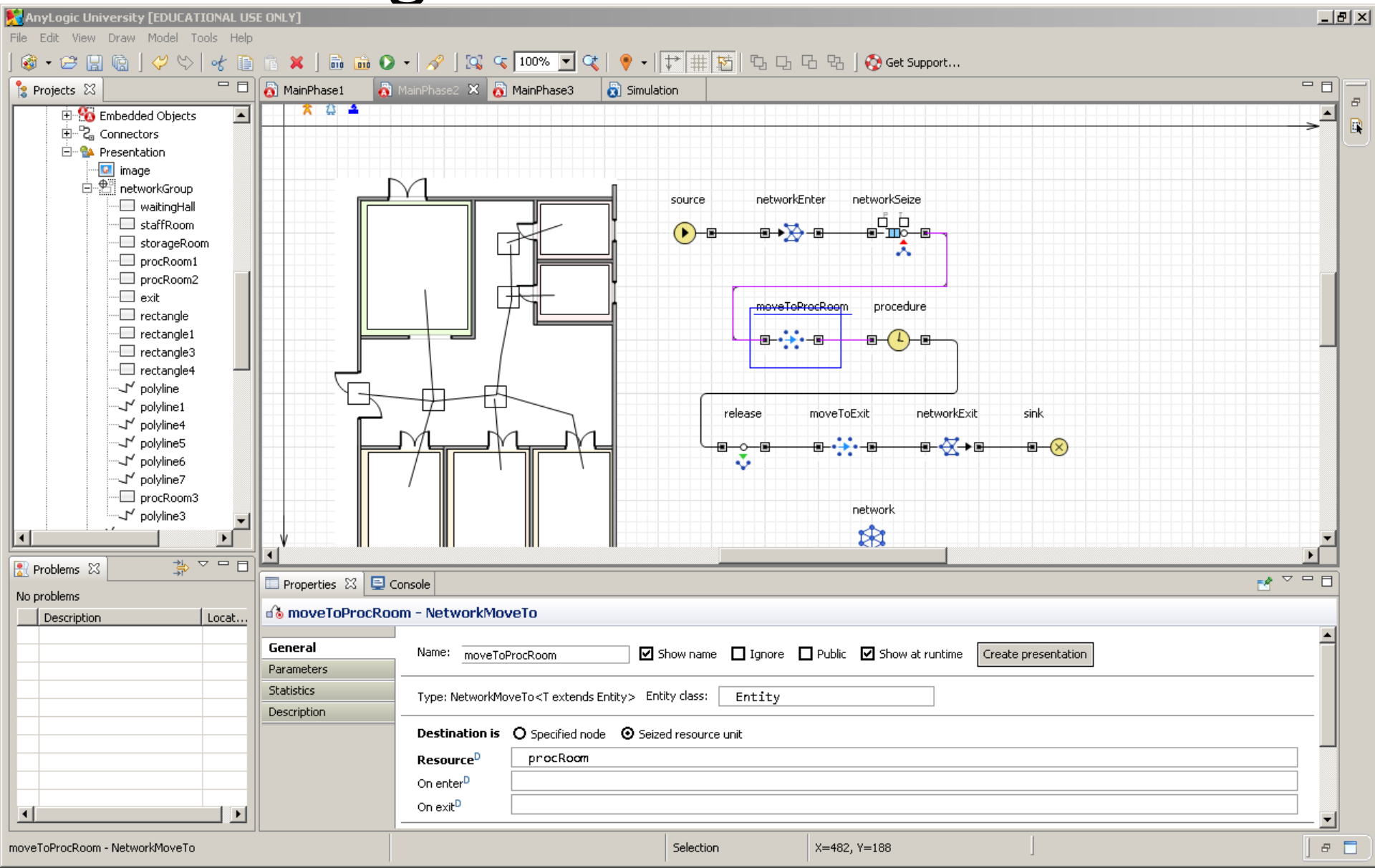
Entering the Network: Same



Reserving (Seizing) a Procedure Room



Moving to the Reserved Room



Releasing the Room